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EVALUATION OF ALTERNATIVE SHIP ORGANIZATIONS.(U)

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(6) EVALUATION OF ALTERNATIVE
SHIP ORGANIZATIONS,

by

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ABSTRACT

This study prescribes and evaluates alternative organizations as potential solutions to the manning imbalance problems identified in the Fleet Manpower Policy Study (FMPS). A number of alternative FF-1052 and FFG-7 class ship organizations are analyzed, with emphasis on the organic maintenance capability of the ship. The principal analytical tool used was the Presearch-developed ship work load algorithm. This study was performed for the Ship Support Improvement Project Office (PMS-306) of the Naval Sea Systems Command under Contract N00024-77-C-4152.

SUMMARY

GENERAL

1. This report analyzes a number of alternative ship's organizations, with emphasis on the ship's capability to accomplish organic maintenance. As an integral part of the Ship Support Improvement Project (SSIP) and a logical follow-on to the Fleet Manpower Policy Study (FMPS), 1/ the analyses are a first effort to prescribe and evaluate solutions to the manning imbalance problems identified in the FMPS. The report documents the identification and development of alternatives and quantifies, via simulations, the anticipated impact of the alternatives on organic work accomplishment.

BACKGROUND

2. The FMPS concluded that the SMD Condition III manning level is, under existing policies, processes and procedures, inadequate to accomplish all the required work in peacetime. This rather general conclusion was based on the criterion that the existence of deferred work in any of the work centers on a ship would constitute inadequate manning. In retrospect, the situation could have been more appropriately described as characterized by a generally inefficient manning composition, with only selective manning inadequacies existing. The mixed pattern of overwork and undertasking exhibited by the work centers attested to this situation.

3. The principal analytical vehicle developed and used in the FMPS was a ship work load (SWL) algorithm, with which the capability of each work center is evaluated relative to the required work load. The utility of that algorithm and the knowledge of ship manning problems gained from the FMPS were recognized as potentially valuable to the isolation and resolution of maintenance manpower questions as part of the overall SSIP.

1/ Presearch Incorporated, Fleet Manpower Policy Study. Technical Report No. 290, 12 February 1976.

PURPOSE

4. The basic study objectives were the following:

- Develop and evaluate alternative forms of FF-1052 and FFG-7 class ship organizations that will potentially improve the organic maintenance capabilities of the ships.
- Examine the impact of recently developed improvements in facilities maintenance and preventive maintenance techniques on the maintenance capability of ships.
- Evaluate the impact on residual maintenance problems (potentially existing after the implementation of alternatives) of moving maintenance tasks to the IMA or depot level.

5. The term "organization," as used in this report, refers to the formal aggregation of work load by work centers, divisions, and departments, as well as the assignment of specific categories and amounts of work load to work centers, collection of skills into ratings, strategies and concepts used to accomplish maintenance, and techniques and procedures used to schedule work for accomplishment.

METHOD OF ANALYSIS

6. The SWL algorithm was the major tool employed for testing and evaluating alternatives, and, where possible, analyses were based on existing data. The four major aspects of the study were:

a. Baseline SWL algorithm sensitivity parameters were developed for each of the ship classes being studied. The baseline input parameters were selected to reflect, as closely as possible, the current organizational situation. Hence, the baseline simulation results described the work load versus capability imbalances as they existed prior to the application of alternatives and provided a basis for determining the impact of alternatives.

b. Alternatives were developed and described in terms of the changes in the SWL algorithm's sensitivity parameters that would occur as a result of each alternative.

c. Alternatives were simulated, either singly or in combinations, and the simulations' results were evaluated based on the changes in deferral patterns occurring relative to the baseline patterns.

d. The impact of work-load transfers to an IMA or depot was determined and evaluated.

7. Baseline data were selected or developed from sources including FF-1052 class SMDs, FF-1052 class notional SMDs prepared by NAVMMACPAC, FMPS data (including the FMPS extension to the FF-1053), a preliminary FFG7 class SMD, FFG-7 in-port watch bills, and the Guide to the Preparation of Ship Manpower Documents (OPNAV 10P-23).

8. The following alternatives were constructed, tested, and evaluated:

- Discrete work-load transfers among work centers.
- New FM concepts--these are based on current Navy initiatives to reduce facilities maintenance man-hour expenditures while improving management of FM and motivation of personnel assigned FM work. The concepts incorporate the use of FM teams to perform FM traditionally assigned to individual work centers; a limited amount of FM-specific training for team members; and the use of labor-saving equipment, materials, and processes.
- Reliability-centered maintenance concepts--these concepts are similar in principle to those used successfully in commercial and Navy aviation maintenance programs. The implementation of the concepts could potentially result in a reduction in preventive maintenance man-hour expenditures without increasing corrective maintenance requirements.
- Work packages describing the ship's force work load during intense in-port maintenance periods--such work packages will be an integral part of the overall maintenance strategy for both classes studied. The maintenance strategies are designed, in part, to increase the at-sea availability of the ships.
- Scheduling of work centers' work load--work is scheduled in a manner that would reduce the peaks in deferred work that occur periodically throughout the operational schedule. All categories of work

load, except for operational manning, are subjected to scheduling based on the capability existing in the work center during each phase of the OPSKED.

- An FF-1052 class formal organization--the organization is based on the predetermined logic of aggregating functions according to both the ship's systems associated with the functions and the nature of the function (e.g., operating equipment or maintaining equipment).
- An FF-1052 class functionally based organization--the organization is based on an aggregation of functions where the basis for each aggregation was determined principally through functional analysis, rather than a predetermined logic.

9. All alternatives were constructed using the baseline (SMD Condition III) total manning level for each class and employing the operational schedule developed for the baseline for each class without modification. This made it possible to measure the impact of alternatives relative to both the baseline and other alternatives.

10. The final simulation conducted for each class was based on a combination of all alternatives. The data bases used for these simulations also served as the foundations for notional SMDs which were developed for each class. These notional SMDs were delivered under separate cover. 2/

11. The impacts of various alternatives or combinations of alternatives were generally evaluated relative to the total changes in work deferral expected to result. Analysis of the changes expected to occur in each work category as a result of the various alternatives was initially limited to that identification possible through the use of broad assumptions and observations on the general nature of work loads assigned to divisions and departments. Ultimately, however, a notional work accomplishment prioritization scheme was constructed and a methodology developed to disaggregate total work deferral into its component work categories. The methodology was used to evaluate the impact of the transfer of residual maintenance work load to an IMA or depot.

RESULTS

12. The study clearly established the feasibility and desirability of addressing manning imbalance problems at the shipboard level first and considering off-ship assistance only after

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2/ Presearch Incorporated, "Modified Ship Manpower Documents," Letter, 22 July 1977.

organization-level alternatives are exhausted. The inadequacy of SMD Condition III manning in a peacetime environment is now seen as a problem that, to a significant degree, arises from inefficient utilization of personnel and not from fundamental undermanning.

13. The specific conclusions of the study are the following:

- The use of organization-level alternatives other than manning increases will significantly enhance the ability of a ship to accomplish all required work
- Organic maintenance deferral may be reduced to a level easily scheduled and accommodated by off-ship support facilities by the implementation of relatively conservative changes in the ship's organization and work-load distribution
- The effectiveness of work-load reductions in improving work-load accomplishment capability can be greatly increased by the simultaneous application of other alternatives
- Existing on-ship scheduling techniques are inadequate to eliminate unnecessary peaks in deferral
- Formal organizations based on functional aggregations by work category and skill level provide the potentially best framework for managing and controlling deferral problems.

14. This study makes the following recommendations:

- An improved scheduling methodology be developed and installed for shipboard use
- The relative priorities of work categories and/or subsets of work categories as well as detractors be officially established and promulgated
- The rationale used to form FM teams from existing ship manning be based on the work load versus capability pattern of each work center
- The implementation of new FM and RCM concepts be accompanied by transfers of discrete work loads among work centers

- Principles of functional analyses be more comprehensively integrated into the ship manpower planning process
- Formal policies regarding the feasibility and necessity of transferring work among work centers and cross-utilizing personnel be established.

IMPLEMENTATION PERSPECTIVE

15. There are actually two major facets to this study. The first, covered by the above conclusions and recommendations, establishes the feasibility of improving organic work capability by the application of organizational alternatives. The second, although a by-product of the basic study, is of equal significance, because it encompasses the insights gained during the study relative to the complexities of implementing the various alternatives and making them work.

16. Effective implementation of a full spectrum of feasible and profitable organizational alternatives will require both an ordered approach and continuing attention to the human factors and managerial impacts attendant to the changes. More specifically, the implementation should include the following considerations:

a. The ship manpower requirements process should be the medium within which the alternatives will be quantified and reflected. The complexities associated with the necessary balancing actions (to minimize work deferral and undertasking among work centers) require a coordinated approach in a systems environment. The requirements determination and documentation system is the logical choice.

b. Shipboard managers must be provided guidance and work-scheduling aids that will enable them to use their manpower resources in a manner consistent with the factors and policies that governed the development of that resource requirement. This will address a basic problem, which, while not peculiar to the Navy, is intensified by a dynamic and often unpredictable work environment aboard Navy ships.

c. A Navy position and governing methodology must be developed on the relative priorities of ship work load, in terms of the categories of work. The priority scheme need not and should not be

so specific or stringent as to impose unnecessarily on the Commanding Officer's prerogatives. However, a system of priorities more specific than the general categories "operate," "maintain," or "administrative/support" must be provided if the Navy is to achieve the goals of *efficient ship manning* and maintenance. A sample priority scheme is contained in Appendix F.

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I. INTRODUCTION

1.1 This report describes the development procedures and methodologies, testing techniques and processes, and significant conclusions associated with a study to determine the impact of alternative organizations on FF-1052 and FFG-7 class ship organic maintenance capabilities. As used here, the term "organization" refers to the formal aggregation of work load by work centers, divisions, branches and departments as well as the collection of skills into ratings, the assignment of specific categories and amounts of work to work centers, the strategies and concepts used to accomplish maintenance and the techniques and procedures used to schedule work. The work was performed for the Commander, Naval Sea Systems Command (PMS-306), under Contract No. N00024-77-C-4152.

BACKGROUND

1.2 The Ship Support Improvement Project (SSIP) is the principal long-term initiative associated with the Chief of Naval Operation's (CNO's) Objective #3, "Improvements of Material Condition in the Fleet." The Director, Ship Modernization and Maintenance Division (OP-43), in the Office of the Chief of Naval Operations is the Navy's central authority for execution of the project, with the Deputy Commander for Fleet Support (SEA-04) within the Material Command functioning as Executive Agent and advising and assisting the Naval Sea Systems Command in coordinating the activities of the project. Management of the project is the responsibility of the Project Manager, Ship Support Improvement Project, PMS-306.

SSIP Objectives and Approach

1.3 The goal of the SSIP is to utilize an integrated, engineered, reliability-centered maintenance strategy to achieve and maintain an adequate material condition of Navy ships in a resource-effective manner. Associated objectives include improving the Navy's understanding of maintenance-related problems, building on earlier, narrower efforts to broaden their applications, providing refinements and/or engineered improvements to existing strategies and techniques, and coordinating and integrating SSIP efforts with other Navy programs affecting maintenance.

1.4 Substantial improvements in all aspects of Navy maintenance have required a comprehensive, long-term analytic effort. Accordingly, the principal objectives of the first element of the SSIP are to be met through a program designed to accomplish the many diverse maintenance-related studies and analyses in an integrated and coordinated manner. Termed the Maintenance System Development Program (MSDP), this effort will concentrate on areas where the payoff is highest and will not only produce a number of completed studies and implementation plans but will generate the understanding and momentum necessary for the Navy to continue to improve the material condition of ships beyond the MSDP programmed expiration date at the end of FY 1980.

Relevant Studies

1.5 In February 1976, Presearch completed the Fleet Manpower Policy Study (FMPS) 1/ for the Chief of Naval Operations (OP-01). In this study the impact of ship manning policies and

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1/ Presearch Incorporated, Fleet Manpower Policy Study, Technical Report No. 290, 12 February 1976.

the operational environment of a ship on its ability to accomplish all required work load were analyzed. During the study the principal factors influencing the accomplishment of total ship work-load requirements, both in port and at sea, in a peacetime environment were identified, quantified and evaluated. The evaluation was facilitated by the use of the ship work load (SWL) algorithm, a time-staged comparison of work load and capability developed during the FMPS.

1.6 The SSIP project manager, PMS-306, noted the relevance of the FMPS effort to SSIP objectives. Not only were the FMPS results and data pertinent to SSIP-related problems, but the utility of the SWL algorithm in direct application to certain elements of the SSIP was recognized. PMS-306 therefore took the initiative first to have the FMPS effort extended to include the FF-1052 class (a class of major interest to SSIP) and next to ensure that the methodologies, algorithm, and experience developed during the FMPS were appropriately brought into play in a study within the MSDP effort. The results of the first initiative are contained in a report completed in October 1976. [2/] This report is the result of the second initiative.

PURPOSE AND SCOPE

1.7 This study was undertaken to explore the effects of various actual or hypothetical alternative ship organizations on the ability of the ship to accomplish its own maintenance. The principal objectives were to:

- Develop alternative forms of FF-1052 and FFG-7 class ship organizations that potentially will improve the organic maintenance capabilities of the ships

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[2/] Presearch Incorporated, Quantification of Work Load Versus Capability Imbalances: FF-1053, Technical Report No. 315, 26 October 1976.

- Examine the impact of recently developed improvements in facilities maintenance and preventive maintenance techniques on the ship's maintenance capability

- Evaluate the impact on residual maintenance problems (potentially existing after the notional implementation of alternatives) of moving select maintenance tasks to the IMA or depot level.

1.8 The SWL algorithm was to be used as the major tool for testing and evaluating alternatives, and, where possible, analyses were to be based on existing data.

CONTENTS

1.9 The following sections contain a full description of the procedures used to establish baselines, develop alternatives, and to test and evaluate the alternatives. The results of the tests and evaluations applicable to each class of ships are presented, as are the conclusions and recommendations arising from the study. Since a complete understanding of the procedures and rationale used to establish the baselines is necessary to properly interpret the effects of alternatives, Section II provides a detailed discussion of the baseline development process. The methodologies and techniques used to develop and evaluate alternative organizations and a description of the alternatives themselves are contained in Section III. Sections IV and V present the test and evaluation results for the FF-1052 and FFG-7 classes, respectively. Section VI addresses the residual maintenance problems that would remain for each class should the alternatives be implemented. Section VII states the conclusions and recommendations.

1.10 The appendices contain material relevant to the study. Appendix A is a narrative description of the ship work load algorithm. Appendix B describes how the FFG-7 class Condition V facilities maintenance and own-unit support were determined. The calculations used to determine the FF-1052 class' utility tasks and administrative support are shown in Appendix C, and material describing the Navy's ongoing Facilities Maintenance Improvement Project (FMIP) is contained in Appendix D. Appendices E and F present, respectively, details on the development of notional work packages for the FF-1052 and FFG-7 classes and a methodology for categorizing work deferral.

ASSOCIATED INFORMATION

1.11 During this study, notional ship manpower documents (SMDs) were developed for the FF-1052 and FFG-7 classes. [3/] These documents reflect the majority of the alternatives described in detail in this report. Since the notional SMDs are written in the general format and terminology of standard SMDs and since a brief overview of the notional SMDs is appended to them, they provide a self-contained summary of a portion of the study effort and results. In view of the size of the notional SMDs, they are not retransmitted at this time. However, where necessary for continuity or clarity, selected extracts from the notional SMDs appear in this report.

[3/] The documents and associated overview have been promulgated as enclosures to Presearch Incorporated's letter of 22 July 1977, "Modified Ship Manpower Documents."

II. BASELINE DEVELOPMENT

2.1 The first step in any effort to develop, test or evaluate the impact of alternatives is to identify and quantify the conditions and parameters to be used to describe the reference situation. The establishment of such a baseline is mandatory to ensure the following:

- Control over variables is maintained
- Audit trails are possible and, hence, causative agents may be well-linked to effects
- Results may be properly interpreted in light of the analyst's knowledge of the baseline.

In addition, a well-defined, realistic baseline serves to assist in identifying potential alternatives, concentrating on alternatives with the highest potential for meeting objectives and producing usable results.

2.2 Ideally, the factors, parameters, conditions and other variables to be included in a baseline would be identified through existing standards, policy statements or, as a minimum, by precedence. Similarly, the quantification of each variable for baseline purposes would occur through the identification of accepted norms, averages, etc. In the particular case at hand, however, no true precedent exists for establishing comprehensive baseline conditions for Navy ships in a peacetime environment. Therefore the development of baselines for the FF-1052 and FFG-7 classes has been necessary as an integral and significant task within this study effort.

DEVELOPMENT RATIONALE

2.3 The primary considerations used in the baseline development process were:

a. The FMPS and follow-on extension of the study to the FF-1053 should provide significant insight into the variables that describe the work-load requirements and work accomplishment capabilities of surface ships operating in a peacetime environment. In some cases, actual values of variables are demonstrated to be acceptable for use in describing the typical or baseline situation. The lessons provided through these studies should be reflected in this effort.

b. The baselines should reflect the status of each class as realistically as possible.

c. The practical constraints surrounding the identification and quantification of both baseline and alternative values must be kept in mind. When existing data is insufficient, accepted principles of management science and engineering practices will be used to approximate values. Factors such as command prerogative and precise interpretation of certain directives and policies add to the complexity of some issues and may necessitate the use of subjective judgments. The fact that such judgments have been used will be clearly noted.

IDENTIFICATION AND QUANTIFICATION OF PARAMETERS

2.4 The parameters that influence the accomplishment of workload requirements and, hence, must be included in the baseline

description are identified in the FMPS. A number of these parameters are included in current SMD development directives; however, the specific values that should be assigned to the parameters vary with the objective in mind. The following paragraphs detail the process by which parameters to be included in the FF-1052 and FFG-7 baselines were selected and quantified. For each parameter the following information is provided:

- Brief description of the parameter
- Alternatives considered
- Alternative selected for use and selection rationale
- Conventions used and data sources
- Baseline value of parameter.

Data Sources

2.5 Subsequent paragraphs refer, in some instances, to specific data sources. The following are the major sources: 1/

- FFG-7 class data
  - Preliminary FFG-7 SMD (FFG-7 PSMD)
  - Condition V watch bill, provided by the ship (FFG-7 Condition V watch bill)
- FF-1052 class data
  - FF-1065 Condition I/III SMD as modified during the FMPS extension to reflect the configuration of the FF-1053 (FF-1065 SMD)
  - FF-1053 notional Conditions IV and V SMDs prepared by the Navy Manpower and Material Analysis Center, Pacific (NAVMMACPAC) (FF-1053 NSMD)

1/ These sources will subsequently be referred to as shown in the parentheses.

- Common data
  - Guide to the Preparation of Ship Manpower Documents (OPNAV 10P-23)
  - FMPS data/results (FMPS)
  - FMPS extension to the FF-1053, study data/results (FMPS extension).

Work Centers

2.6 The term "work center" describes the basic level at which work load and capability will be described, computed or manipulated. Alternative work center definitions possible are rate and ratings, rating within a division, or division. A work center is defined as a rating within a division. This is consistent with the FMPS definition and ship work load (SWL) algorithm input requirements and allows for sufficient detail to be maintained without exceeding the specificity achievable through the use of existing data sources.

2.7 The convention used is to code the division and the rating; for example, Work Center Code M MM identifies machinist mates in M division. The division and rating designations used are those prescribed in existing FF-1052 and FFG-7 class SMDs. Baseline work centers are listed in a number of the tables associated with subsequent parameters.

Operational Schedule (OPSKED)

2.8 The operational schedule (OPSKED) defines the phase (maintenance, operation, exercise, training, inspection, etc.) that the ship is undergoing at any point in time. The total length of the OPSKED to be considered, the phases included, and the

duration and sequencing of phases all impact on the work load and capability of the ship. Alternatives considered were:

- Typical OPSKEDs covering the period between regular overhauls with deployed periods treated as all at sea
- Typical OPSKEDs covering a period between regular overhauls with the normal at-sea and in-port phases reflected in both the CONUS and deployed periods
- Actual OPSKEDs reconstructed from ship's records.
- Notional OPSKEDs derived from typical OPSKEDs and incorporating certain features facilitating their use.

The last alternative was selected for use. No historical OPSKED existed for the FFG-7, and available data concerning historical OPSKEDs for the FF-1052 class covered a period too short to be useful in this effort. Existing typical OPSKEDs, such as those developed in the FMPS extension to the FF-1053, could not be used for baseline purposes, since these OPSKEDs would have required significant changes midway through the study to be used in conjunction with potential work-load scheduling alternatives.

2.9 Notional operating schedules for both classes were developed. The notional FF-1052 class operational schedule was derived by using data provided by the Chief of Naval Operations (OP-642) for the FMPS extension and incorporating modifications to accommodate the changes imposed by prospective alternative maintenance strategies. Deployment and maintenance periods were superimposed into the schedule, and the schedule was extended to 234 wk (the length of the EOC) by including phases

similar to those projected in existing schedules. In-port phases were described as either Auxiliary Steaming or Cold Iron to reflect the differences in work loads between these conditions.

2.10 The notional FFG-7 operational schedule was formulated using typical FF-1052 and DDG-2 class ship operational schedules as a guide. No FFG-7 planned deployment cycle had been formulated at the time; therefore, Naval Sea Systems Command's (PMS-399) inputs, which indicated that this class would probably follow the same deployment scheme as that of the FF-1052 class, were used to structure 6-month deployments with a 12-month turn-around. The deployments and prospective maintenance periods were plotted, and phases similar to those scheduled for the FF-1052 were assigned throughout the remainder of the 234-wk cycle. The phase names and collectors used to describe the FF-1052 and FFG-7 notional operating cycle are shown in Tables 2.1 and 2.2, respectively. Note that only minor differences in the names of maintenance phases exist between the two tables. Maintenance phase names displayed are those associated with certain alternative maintenance strategies discussed later in this report. For baseline purposes, all maintenance phases except overhauls were treated identically, since the work loads and capabilities for each work center are the same during each maintenance phase. The notional OPSKEDs developed for each class are shown in Tables 2.3 and 2.4.

Manning Levels

2.11 Manning level refers to the total number of personnel identified with each work center. Manning levels considered for baseline use fall into two categories: prescribed and effected. Prescribed manning levels include SMD Condition III, SMD Condition IV, SMD Condition V, and Manpower Authorization

TABLE 2.1

PHASE NAMES AND ABBREVIATIONS--FF-1052 CLASS

Environment/Function		Phase Identifications			Phase Name "Collector"	
		No.	Category	Abbrev.	Category	Abbrev.
Maintenance		1.	Baseline overhaul	BOH	Same	Same
		2.	Regular overhaul	ROH	Same	Same
		3.	Technical availability (tender)	TAV	Same	Same
		4.	Selected restricted availability	SRA	Same	Same
At Sea	Operations and Exercises	5.	Fleet exercises	FLEET-EX	Fleet exercises	FLTEX
		6.	Multiple ship exercises	READI-EX		
		7.	Missile exercises	MSLEX		
		8.	Anti-submarine warfare exercises	ASWEX		
		9.	Independent steaming exercises	ISE	Independent steaming exercise	ISE
		10.	Operational propulsion plant examination	OPPE		
		11.	Plane guard	PLG	Escort service	ESC
		12.	Escort services	ESC		
		13.	Group sail	GRUSL	Group sail	GRUSL
		14.	Multisail	MLTSL		
		15.	Enroute	ENR	Same	Same
	Training	16.	Mobile team training	MTT	Same	Same
		17.	Refresher training	RFT	Same	Same
		18.	Type training	TYT	Type training	TYT
		19.	Coordinated anti-submarine services training	CAST		
		20.	Weapons system acceptance training	WSAT		
In Port	Operation, Exercises, and Inspections	21.	Upkeep	UPK	Upkeep	UPK
		22.	In-port	IPT		
		23.	Brief stop	MA/BSP		
		24.	Visit	VST		
		25.	Nuclear weapons acceptance inspection	NWAI		
		26.	Medical inspector	MEDINSP		
		27.	Technical standardization inspection	TSI		
		28.	Leave and upkeep	LVUPK	Same	Same
		29.	Ready for sea	RFS	Ready for sea	RFS
		30.	Preparation for overseas movement	POM		
		31.	Load out	LOAD	Load/off-load	LD/OL
		32.	Off load	OFLD		
	Training	33.	Training availability	TRAV	Training availability	TRAV
		34.	Nuclear weapons acceptance training	NWAT		
		35.	Unit training	UNITNG		
		36.	Combat systems readiness training	CSRG		

TABLE 2.2

PHASE NAMES AND ABBREVIATIONS-- FFG-7 CLASS

Environment/ Function		Phase Identifications			Phase Name "Collector"	
		No.	Category	Abbrev.	Category	Abbrev.
Maintenance		1.	Baseline overhaul	BOH	Not used	–
		2.	Regular overhaul	ROH	Not used	–
		3.	Intermediate maintenance availability	IMAV	Same	Same
		4.	Selected restricted availability	SRA	Same	Same
At Sea	Operations and Exercises	5.	Fleet exercises	FLEET-EX	Fleet exercises	FLTEX
		6.	Multiple ship exercises	READI-EX		
		7.	Missile exercises	MSLEX		
		8.	Anti-submarine warfare exercises	ASWEX		
		9.	Independent steaming exercises	ISE	Independent steaming exercise	ISE
		10.	Operational propulsion plant examination	OPPE		
		11.	Plane guard	PLG	Escort service	ESC
		12.	Escort services	ESC		
		13.	Group sail	GRUSL	Group sail	GRUSL
		14.	Multisail	MLTSL		
		15.	Enroute	ENR	Same	Same
	Training	16.	Mobile team training	MTT	Same	Same
		17.	Refresher training	RFT	Same	Same
		18.	Type training	TYT	Type training	TYT
		19.	Coordinated anti-submarine services training	CAST		
		20.	Weapons system acceptance training	WSAT		
In Port	Operation, Exercises, and Inspections	21.	Upkeep	UPK	Upkeep	UPK
		22.	In-port	IPT		
		23.	Brief stop	MA/BSP		
		24.	Visit	VST		
		25.	Nuclear weapons acceptance inspection	NWAI		
		26.	Medical inspector	MEDINSP		
		27.	Technical standardization inspection	TSI		
		28.	Leave and upkeep	LVUPK	Same	Same
		29.	Ready for sea	RFS	Ready for sea	RFS
		30.	Preparation for overseas movement	POM		
		31.	Load out	LOAD		
		32.	Off load	OFLD		
	Training	33.	Training availability	TRAV	Training availability	TRAV
		34.	Nuclear weapons acceptance training	NWAT		
		35.	Unit training	UNITNG		
		36.	Combat systems readiness training	CSRG		

TABLE 2.3

FF-1052 CLASS NOTIONAL OPERATING SCHEDULE
(BOH to ROH)

Week	Phase	Week	Phase	Week	Phase	Week	Phase	Week	Phase
--	BOH	39-40	GRUSL	94	UPKAS	140-142	TAV	190	UPKCI
1-2	RFSAS	41-43	TAV	95-97	TAV	143	ISE	191-193	TAV
3	ISE	44-47	ESC (S)	98	ISE	144-145	TYT	194	TAAV
4-5	UPKCI	48	RFSAS	99	ENR	146-147	ENR (E)	195-196	FLTEX
6-7	RFT	49-50	TYT	100-101	GRUSL	148-151	LVUPK	197-198	UPKCI
8-9	UPKCI	51	TRAV	102-103	UPKCI	152-153	TYT	199-200	ESC (S)
10	MTT	52-53	UPKCI	104-106	FLTEX	154	ISE	201-202	FLTEX
11	ENR	54-55	GRUSL	107-108	UPKCI	155-157	TAV	203	UPKAS
12	ISE	56-58	TAV	109	ISE	158-163	SRA	204	ISE
13-15	TAV	59-60	GRUSL	110-112	TAV	164	ISE	205	ENR
16-17	UPKAS	61-62	FLTEX	113-114	ESC	165-166	GRUSL	206-208	TAV
18	MTT	63	ENR	115	LD/OL	167	FLTEX	209-210	FLTEX
19	FLTEX	64-65	UPKAS	116-117	TYT	168	ENR	211-212	UPKCI
20	RFSCI	66	ISE	118-119	UPKCI	169-170	ESC	213-214	ESC
21-24	UPKCI	67	FLTEX	120	TRAV	171-172	UPKCI	215	TYT
25	FLTEX	68-69	ENR (E)	121-123	ESC (S)	173-174	TRAV	216-217	UPKAS
26	UPKAS	70-73	LVUPK	124	FLTEX	175	TYT	218-219	FLTEX
27	TRAV	74-76	TAV	125-127	TAV	176-178	TAV	220	UPKCI
28-30	TAV	77-82	SRA	128-129	TYT	179	ENR	221-223	TAV
31	ISE	83-84	TYT	130-131	UPKAS	180-181	FLTEX	224-225	ENR (E)
32	UPKCI	85-86	FLTEX	132-133	FLTEX	182-183	UPKCI	226-229	LVUPK
33	FLTEX	87	ISE	134	ENR	184	TYT	230-232	TAV
34	LD/OL	88-89	UPKCI	135-136	UPKCI	185-186	UPKCI	233	LD/OL
35-36	UPKCI	90-91	ISE	137-138	ESC	187	ISE	234	UPKCI
37-38	RFSAS	92-93	FLTEX	139	UPKAS	188-189	TYT	--	ROH

Note: RFS and UPK are further described by the suffix AS (auxiliary steaming) or CI (cold iron)
S = start deployment
E = end deployment

TABLE 2.4

FFG-7 CLASS NOTIONAL OPERATING SCHEDULE
(through second SRA)

Week	Phase	Week	Phase	Week	Phase	Week	Phase	Week	Phase
1-2	RFS	43-45	GRUSL(S)	94	MTT	139	ENR	185-187	UPK
3	ISE	46	FLTEX	95	ENR	140	UPK	188	TRAV
4-5	UPK	47	ENR	96	ISE	141-143	IMAV-4	189	ISE
6-8	RFT	48-49	ESC	97-98	UPK	144-145	GRUSL	190-191	UPK
9-10	UPK	50-51	UPK	99	MTT	146	ENR (E)	192-193	FLTEX
11	FLTEX	52	ISE	100	FLTEX	147-150	LVUPK	194-195	UPK
12	UPK	53-54	FLTEX	101-103	UPK	151-153	TYT	196-198	RFS
13-14	TYT	55	UPK	104	TRAV	154	FLTEX	199-201	GRUSL(S)
15	UPK	56-58	IMAV-2	105	ISE	155	ENR	202-204	IMAV-6
16	ESC	59	TYT	106-107	UPK	156-157	ESC	205	FLTEX
17	FLTEX	60	ENR	108-109	FLTEX	158-159	UPK	206	ENR
18-19	UPK	61-62	FLTEX	110-111	UPK	160-161	ISE	207-208	ESC
20	MTT	63	ENR	112-115	SRA-1	162-163	UPK	209-210	UPK
21	ENR	64-65	UPK	116	TYT	164	ENR	211	ISE
22	ISE	66-67	GRUSL	117-119	RFS	165-166	FLTEX	212	TYT
23-24	UPK	68	ENR (E)	120-122	GRUSL(S)	167-169	UPK	213	ENR
25	MTT	69-72	LVUPK	123	UPK	170	ISE	214-215	FLTEX
26	UPK	73-75	TYT	124	FLTEX	171	UPK	216	ENR
27-29	IMAV-1	76	FLTEX	125	ENR	172-174	IMAV-5	217-218	UPK
30	FLTEX	77	ENR	126-127	ESC	175	TYT	219	TYT
31	UPK	78-79	ESC	128	UPK	176	UPK	220-221	UPK
32	TYT	80-81	UPK	129	ISE	177	ISE	222-223	GRUSL
33	TRAV	82-83	ISE	130	UPK	178	MTT	224	ENR (E)
34	ISE	84	UPK	131-132	FLTEX	179	ENR	225-228	LVUPK
35-36	UPK	85-87	IMAV-3	133-134	UPK	180	ISE	229	ISE
37-38	FLTEX	88-89	FLTEX	135	TYT	181-182	UPK	230	UPK
39	UPK	90-92	UPK	136-137	ESC	183	MTT	231-234	SRA-2
40-42	RFS	93	ISE	138	UPK	184	FLTEX	–	–

S = start deployment

E = end deployment

(OPNAV 1000/2). Effected manning levels include actual weekly or average historical levels for each work center and selectively designated levels for each work center.

2.12 SMD Condition III manning levels were selected for use in the baselines. Several factors impacted on this decision. First, although this effort primarily addresses the peacetime situation, the ability to achieve a wartime posture must be maintained. Second, significant amounts of work-load data were extracted from SMDs; hence, the use of an SMD-prescribed manning level was appropriate. Finally, the analyses of alternatives can be more meaningfully oriented to requirements than to some other manning level, such as an effected level or manpower authorization level. While manpower authorizations are, in fact, based on requirements, they often reflect variances due to budgetary constraints that would unduly distort the effort.

2.13 Manning levels for each work center were constructed from the FF-1052 SMD and the FFG-7 PSMD. The following conventions were used:

- Where a billet identification for a billet in a given division reflects a rating, the billet was associated with the work center bearing the same division and rating codes. All petty officer and designated striker billets were immediately assigned to work centers by this method.
- Where the billet identification shows only the general apprenticeship, additional information such as the billet title, associated NEC, condition stations assigned and relative position of the billet in the total divisional listing was used to identify the associated work center. SN/SA/SR and FN/FA/FR billets were handled in this manner.

The manning levels for each work center for each class are shown in Tables 2.5 and 2.6.

Formal Organization

2.14 The formal organization is described by the aggregations used in collecting billets into work centers, work centers into divisions, and divisions into departments. Alternatives considered for baseline purposes were the actual ship's organization, the organization depicted in OPNAV 1000/2, and the organization depicted in the SMD. The SMD organization was selected for use in the baseline to provide consistency with the workload data used and the manning levels established. The FF-1065 SMD and the FFG-7 PSMD were used to determine the formal organization for the respective classes. This formal organization is implicitly displayed in Tables 2.5 and 2.6.

Work Load

2.15 Work load is expressed in terms of the hours required to accomplish productive tasks. Unless otherwise specified, manpower allowances such as productive and make-ready/put-away factors are treated as being incidental to the basic work load and are not included in the work-load values. Candidate data sources were work loads described in existing SMDs, work loads identified through activity sampling, and work loads calculated by using relevant sources such as SMD backup material and data collected in other studies. For baseline purposes, a combination of candidate work loads was used. The intent was to utilize work loads that would realistically reflect those present in a peacetime environment.

TABLE 2.5
FF-1052 CLASS BASELINE MANNING
AND ORGANIZATION

Department	Work Center		Baseline Manning
	Division	Rating	
Executive	X	PO	1
	X	MA	1
	X	PC	1
	X	PN	3
	X	YN	2
Navigation	N	QM	5
Medical	H	HM	2
Operations	OC	RM	13
	OC	SM	6
	OE	ET	6
	OI	EW	7
	OI	OS	29
Air	AD	SN	2
Weapons	D1	BM	35
	D1	YN	1
	D2	GMG	8
	F	FTG	6
	F1	FTM	7
	F2	GMT	7
	F2	STG	19
	F2	TM	2
Engineering	A	EN	2
	A	MM	6
	A	MR	1
	A	YN	1
	B	BT	31
	E	EM	7
	E	IC	5
	M	MM	27
	R	HT	14
Supply	S1	SK	7
	S2	MS	18
	S3	SH	5
	S4	DK	2
	S5	MS	8
Total	--	--	297

TABLE 2.6

FFG-7 CLASS BASELINE MANNING AND ORGANIZATION

Department	Work Center		Baseline Manning
	Division	Rating	
Ship Control	SC1	QM	7
	SC1	SM	9
	SC2	RM	10
	SC3	BM	14
Combat Systems	CS1	OS	12
	CS1	EW	3
	CS2	ST	8
	CS2	TM	1
	CS3	FT	10
	CS3	GMM	2
	CS3	GMG	3
	CS4	ET	6
	CS4	DS	2
	CS4	IC	3
Engineering	E1	EN	6
	E1	EM	4
	E2	MR	1
	E2	EN	8
	E2	EM	7
	E2	HT	4
Support	S1	MA	1
	S1	YN	3
	S1	PN	1
	S1	SK	5
	S1	DK	1
	S1	HM	1
	S2	MS	15
	S2	SH	6
Total	--	--	153

2.16 Work loads are expressed in hours per week for each work center for each condition encountered in the operational schedule. Standard conventions are used to identify categories of work load (e.g., PM, CM, FM). Work-load sources used to describe the baseline situation are identified in Table 2.7.

Work-Load Variances

2.17 The work loads discussed in Paragraph 2.15 reflect variations between the at-sea and in-port conditions. The SWL algorithm allows the user the further option of considering variations in one or more work categories that may occur among specific phases. For example, the amount of PM accomplished by a work center during a fleet exercise may be different than that accomplished during an independent steaming exercise, even though both exercises are accomplished at sea. Such phase-by-phase differences are referred to as work-load variances.

2.18 Work-load variances considered for use in the baseline were PM variances determined from data collected from fleet commanders during the FMPS, PM variances calculated from FF-1053 inputs during the FMPS extension, PM variances based on one or both of the above listed variances but adjusted to eliminate certain undesirable characteristics as described in the following paragraph and notional work-load variances.

2.19 An analysis of the FMPS and FMPS extension PM variances showed that the direct application of these variances would generate a net reduction in work load (i.e., phases during which a lower than average amount of PM was accomplished had been identified, but phases (if any) during which a higher than average amount of PM was accomplished had not been identified).

TABLE 2.7
BASELINE WORK LOAD SOURCES

Phase	Class	Source
All at-sea phases	FF-1052	Condition IV work loads as shown in the FF-1053 NSMD. Note that these work loads are the same as those shown in the FF-1065 SMD, except for Operational Manning (OPMAN) work load.
	FFG-7	Work loads shown in the FFG-7 PSMD.
All in-port phases	FF-1052	Condition V work loads shown in the FF-1053 NSMD. Note that these work loads are based on an activity sampling conducted during the FMPS extension and include OPMAN work load for both auxiliary steaming and cold iron conditions.
	FFG-7	Condition V OPMAN work load was derived from the FFG-7 Condition V watch bill. Condition V PM and CM values are those shown in the FFG-7 PSMD. Condition V FM and OUS (UT and A/S) values were derived by multiplying the FFG-7 PSMD FM and OUS work loads for each work center by a ratio of Condition V to Condition III work load for that work center and category. The ratios were developed from data collected in the FMPS and FMPS extension. Appendix B provides a detailed explanation of the process and results.

A procedure was available to compensate for this effect; however, the process basically assumed that PM that was not accomplished during at-sea phases would be accomplished in port. Results of activity sampling conducted during the FMPS and FMPS extension did not support this assumption. Notional work-load variances could have been developed at this point to simulate phase-by-phase differences in work load; however, the development of such variances was perceived as more appropriate for accomplishment during the portion of the study dealing with the development and testing of alternative organizations. In the final analysis, the decision was made to use the work loads described in Paragraph 2.15 with no variances applied for baseline purposes.

Work Factors and Productive Allowances

2.20 The work loads discussed in Paragraph 2.15 are the average times required for actual work-load accomplishment. It is necessary to adjust these times to allow for the accomplishment of associated tasks (make ready, put away and data recording) and to reflect delays due to fatigue, environmental effects, personal needs and unavoidable interruptions that will occur during work. Work and productive allowances are applied to appropriate work categories to properly translate the basic work load (hours per week) into the times actually required for accomplishment (man-hours per week).

2.21 Alternatives considered for baseline purposes were OPNAV 10P-23 values and other values, such as those empirically derived from FMPS data. OPNAV 10P-23 work factors and productive allowance values were used for the baseline (and throughout the entire study effort), since these values were derived from a data base considerably larger than that associated with the FMPS.

2.22 Work factors and productive allowances are expressed as a percentage of the time required to accomplish the tasks in a given work category. In dealing with the SWL algorithm, the percentages are converted to factors that allow for direct multiplication to be used. Various factors are associated with the different work categories as specified in OPNAV 10P-23. The work factor (hereafter referred to as make-ready/put-away (MR/PA)) allowance and the productive allowance used are shown in the following table.

Work Category	MR/PA, %	Productive Allowance, %	SWL Algorithm Expression
OPMAN	--	--	OPMAN
PM	30	20	(1.3)(1.2)PM
CM	--	20	(1.2)CM
FM	--	20	(1.2)FM
OUS (UT + A/S)	--	20	(1.2)OUS

Workweek

2.23 The basic productive time available for accomplishment of work is constrained by the total workweek (in hours) used. Alternatives considered for baseline purposes were the Navy standard workweek afloat as set forth in OPNAV 10P-23 and notional workweeks. The former was selected as the only acceptable alternative, with OPNAV 10P-23 values and conventions used to describe the workweek. The following table reflects the Navy standard workweek:

Condition	Workweek, hr	Application
At sea	74	Watchstanders
	66	Non-watchstanders
In port	45	Watchstanders
	41	Non-watchstanders

Note that in determining the number of watchstanders required to stand a watch, OPNAV 10P-23 conventions are also used (i.e., 1 watchstander for each 56 hr of watch at sea, 1 watchstander for each 9.33 hr of watch in port).

Productivity Detractors

2.24 A number of factors reduce a person's availability for productive effort during the workweek. All such factors are treated in this study as detractors. These detractors are service diversions, training, leave, and ineffectiveness (unauthorized absences (UA), temporary additional duty (TAD)). Alternative productivity detractors considered for use were those shown in OPNAV 10P-23, those generated during the FMPS and/or FMPS extension, and modified FMPS factors.

2.25 All three alternatives were used in the baseline. The decision to use a given value for a parameter was based on the objective of selecting the value that most accurately reflected the true situation. In some cases, FMPS values (based on data collected during the study) were used directly. In the case of leave, a modification was made to the FMPS average values to reflect a more realistic picture of the manner in which leave would actually be taken. Where the FMPS effort provided no additional data or insight, OPNAV 10P-23 values were selected.

2.26 In general, productivity detractors are expressed in hours per billet per week. In the case of training, certain elements are expressed in hours per billet per year, hours per week, or hours per year. Table 2.8 summarizes information concerning the detractors used. Tables 2.9 and 2.10 list work-center specific values referred to in Table 2.8.

TABLE 2.8

PRODUCTIVITY DETRACTORS

Detractor	Source/Comments	Values Used
Service diversions	OPNAV 10P-23	Non-watchstanders: 4.00 hr/wk (all phases); watch-standers: 3.17 hr/wk at sea, 3.85 hr/wk in port
Training	FMPS extension data (FF-1052 class); FMPS extension data extrapolated to the FFG-7 (FFG-7 class). Training used is composite training requirement as defined in FMPS and quantified in FMPS extension	Varies with work center, see Tables 2.9 and 2.10
UA	FMPS average values	At sea: 0.242 hr/billet/wk; in port: 0.357 hr/billet/wk
TAD	FMPS average values	At sea: 0.452 hr/billet/wk; in port: 0.387 hr/billet/wk
Leave	FMPS values, modified to reflect intense leave during LVUPK phase (see leave Option 4, Appendix A)	At sea: 1.45 hr/billet/wk; in port, except LVUPK, 1.52 hr/billet/wk; LVUPK: see Tables 2.9 and 2.10

TABLE 2.9

FF-1052 CLASS BASELINE, TRAINING AND LEAVE
(DURING LVUPK)

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
X	PO	18.21	0.00	0.00	0.00	0.00
X	MA	18.21	0.00	0.00	0.00	0.00
X	PC	16.63	3.35	0.08	10.67	72.67
X	PN	16.12	3.60	0.00	37.27	56.34
X	YN	15.78	3.44	0.67	66.22	89.33
N	QM	15.30	3.94	1.05	44.39	408.00
H	HM	15.32	4.89	0.55	16.01	104.00
OC	RM	16.21	3.48	0.80	21.55	400.66
OC	SM	16.06	3.30	3.00	43.34	32.00
OE	ET	13.32	5.09	1.12	90.67	858.66
OI	EW	15.28	2.81	0.77	68.00	1,053.33
OI	OS	13.29	8.20	1.54	22.67	3,102.67
AD	SN	15.94	3.64	0.00	31.67	0.00
D1	BM	15.63	3.65	15.08	39.52	4,447.99
D1	YN	15.53	3.43	0.00	62.22	0.00
D2	GMG	15.72	4.82	2.64	17.07	629.33
F	FTG	15.27	4.72	1.02	44.95	525.34
F1	FTM	15.38	4.26	0.75	40.38	278.67
F2	GMT	15.18	4.49	3.31	28.17	899.59
F2	STG	15.11	4.98	2.42	37.33	637.34
F2	TM	14.79	5.78	1.33	42.67	194.67
A	EN	12.89	4.97	0.91	23.11	738.67
A	MM	13.64	4.40	1.18	78.40	990.72
A	MR	15.26	3.91	0.32	10.67	186.67
A	YN	15.28	3.43	0.34	62.22	44.67
B	BT	16.30	3.92	3.83	15.06	2,260.39
E	EM	14.72	4.66	1.62	16.77	1,296.00
E	IC	14.60	4.62	1.14	19.74	996.00
M	MM	13.64	4.42	6.24	76.21	5,164.29
R	HT	13.49	6.90	2.70	72.89	2,157.32
S1	SK	16.00	2.69	0.53	30.94	64.00
S2	MS	15.47	3.43	6.74	32.31	1,494.09
S3	SH	15.68	3.85	2.01	21.34	448.01
S4	DK	16.13	3.60	0.12	34.67	2.67
S5	MS	15.85	3.33	1.22	30.01	501.59

TABLE 2.10

FFG-7 CLASS BASELINE, TRAINING AND LEAVE (DURING LVUPK)

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
SC1	QM	15.57	3.71	2.94	40.46	964.00
SC1	SM	16.06	3.30	3.00	43.34	32.00
SC2	RM	16.21	3.48	0.80	21.55	400.66
SC3	BM	15.57	3.65	13.20	38.54	3,891.99
CS1	OS	13.29	8.20	1.54	22.67	3,102.67
CS1	EW	15.28	2.81	0.77	68.00	1,053.33
CS2	ST	15.11	4.98	2.42	37.33	637.34
CS2	TM	14.79	5.78	1.33	42.67	194.67
CS3	FT	15.27	4.72	1.02	44.95	525.34
CS3	GMM	15.72	3.27	4.67	78.89	119.99
CS3	GMG	15.72	4.82	2.64	17.07	629.33
CS4	ET	13.32	5.09	1.12	90.67	858.66
CS4	DS	14.30	3.70	6.03	192.13	297.33
CS4	IC	14.60	4.62	1.14	19.74	996.00
E1	EN	12.89	4.97	0.91	23.11	738.67
E1	EM	14.72	4.66	0.69	16.77	555.43
E2	MR	15.26	3.91	0.32	10.67	186.67
E2	EN	12.89	4.97	0.91	23.11	738.67
E2	EM	14.72	4.66	0.92	16.77	740.57
E2	HT	13.49	6.90	1.54	72.89	1,232.75
S1	MA	18.21	0.00	0.00	0.00	0.00
S1	YN	15.59	3.44	1.01	64.22	134.00
S1	PN	16.12	3.60	0.00	37.27	56.34
S1	SK	16.00	2.69	0.53	30.94	64.00
S1	DK	16.13	3.60	0.12	34.67	2.67
S1	HM	15.32	4.89	0.55	16.01	104.00
S2	MS	15.59	3.40	7.96	31.60	1,995.68
S2	SH	15.68	3.85	2.01	21.34	448.01

BASELINE RESULTS

2.27 The baseline parameters are summarized in Table 2.11. Similar summary tables will be used throughout this report to indicate parameters employed to simulate alternative organizations.

2.28 The baseline parameters were applied as inputs to the SWL algorithm and the resultant deferral observed at the end of the 234-wk cycle and at nine points within the cycle. The results are shown in Tables 2.12 and 2.13.

2.29 For each work center, the information in the following paragraphs is displayed in the tables. First, deferral is considered as a percentage of total work load. The minimum value is the lowest percentage of deferral observed at any of the 10 observation points in the cycle. The maximum value is the highest percentage of deferral observed at any of the observation points. The percentage of deferral existing at the last point, the end of the cycle (EOC), is also given. As shown in the FMPS and FMPS extension, the EOC deferral alone may not be a complete indicator of potential problems within a work center since the deferral accumulated at various points within the cycle may be significantly higher than the EOC deferral. For example, in Table 2.12 Work Center OE ET has 11.2% deferral at EOC; however, the deferral at one or more observation points interior to the operating schedule is over 20%. For this work center, the minimum deferral observed at any of the interior observation points is 9%. The use of these values to describe the deferral gives a general picture of the manner in which the work center deferral varies during the operating cycle. Note that the detailed phase-by-phase variations in deferral

TABLE 2.11
BASELINE PARAMETERS

Parameter	Source
Work centers	Division/ratings. From SMDs
OPSKEDs	Notional 234-wk schedule
Manning	SMD Condition III: FF-1065 SMD, FFG-7 PSMD
Formal organization	FF-1065 SMD; FFG-7 PSMD
Work loads	
At sea	SMD Condition IV: FF-1053 NSMD, FFG-7 PSMD (equivalent to Condition III)
In port	FF-1053 NSMD (Condition V); FFG-7 PSMD (PM, CM), FFG-7 Condition V watch bill (OPMAN), FFG-7 PSMD modified by FF-1053 ratios (FM, OUS (UT, A/S))
Work-load variances	Not used
Work and productive allowances	OPNAV 10P-23
Workweek	Navy standard workweek (OPNAV 10P-23)
Detractors	
Service diversions	OPNAV 10P-23
Training	FMPS extension composite authority: directly for FF-1052 class, prorated for FFG-7 class
UA/TAD	FMPS average values
Leave	FMPS average (at sea), FMPS average modified (in port)

TABLE 2.12
FF-1052 CLASS BASELINE STATUS

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
X	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	PC	0.0	1.3	0.1	0.60	8.2	0.4	0.0
X	PN	0.0	1.9	0.0	1.36	3.4	1.1	0.0
X	YN	46.4	52.5	47.6	10.18	0.0	1.5	13.6
N	QM	0.0	1.6	0.3	3.71	3.5	1.9	0.1
H	HM	0.0	1.2	0.0	1.06	6.2	0.9	0.0
OC	RM	0.0	0.0	0.0	-0.22	7.1	4.6	0.0
OC	SM	0.0	0.3	0.0	0.41	13.5	2.2	0.0
OE	ET	9.0	20.4	11.2	13.49	0.0	2.3	4.8
OI	EW	0.0	0.8	0.0	1.05	15.7	1.0	0.0
OI	OS	0.0	0.0	0.0	-8.89	4.0	4.0	0.0
AD	SN	0.0	0.0	0.0	-0.74	52.4	0.3	0.0
D1	BM	6.3	7.8	7.1	40.18	0.0	15.1	20.5
D1	YN	0.0	0.0	0.0	-0.04	41.6	0.2	0.0
D2	GMG	0.0	1.7	0.4	6.75	0.9	3.0	0.3
F	FTG	0.0	1.8	0.3	4.44	16.7	1.9	0.1
F1	FTM	0.0	0.0	0.0	-2.78	15.5	0.7	0.0
F2	GMT	0.0	0.0	0.0	-0.63	16.0	1.3	0.0
F2	STG	0.0	0.3	0.0	2.09	5.4	5.3	0.0
F2	TM	13.2	16.6	14.3	3.49	0.0	0.9	2.3
A	EN	39.2	44.5	40.1	4.50	0.0	1.0	7.8
A	MM	23.0	26.5	24.0	10.52	0.0	2.7	12.5
A	MR	0.0	1.9	0.4	0.71	8.2	0.3	0.0
A	YN	0.0	0.0	0.0	-0.04	39.9	0.2	0.0
B	BT	0.0	0.8	0.0	12.79	3.1	11.9	0.0
E	EM	18.2	20.5	18.5	5.94	0.0	3.1	11.0
E	IC	4.5	6.3	5.4	4.96	0.0	1.9	2.0
M	MM	0.0	3.4	0.6	20.36	0.5	9.8	1.2
R	HT	0.0	1.4	0.2	9.64	5.3	4.6	0.2
S1	SK	0.0	0.0	0.0	0.14	14.7	2.1	0.0
S2	MS	10.2	11.9	11.2	21.13	0.0	7.5	16.0
S3	SH	15.9	17.1	16.6	7.15	0.0	2.2	7.0
S4	DK	0.7	2.2	1.6	2.09	0.0	0.8	0.2
S5	MS	0.0	1.4	0.1	4.79	4.4	2.9	0.1
Total ship		4.9 1/	6.2 2/	5.3 1/	193.53 2/	12.3 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 2.13
FFG-7 CLASS BASELINE STATUS

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
SC1	QM	0.0	0.0	0.0	0.22	14.0	3.8	0.0
SC1	SM	0.0	0.2	0.0	0.68	9.8	5.5	0.0
SC2	RM	0.0	0.1	0.0	1.85	9.1	6.0	0.0
SC3	BM	43.1	45.9	45.9	62.08	0.0	13.7	34.9
CS1	OS	9.9	11.1	11.0	9.79	0.0	7.6	4.6
CS1	EW	0.0	1.7	0.0	1.57	38.0	0.6	0.0
CS2	ST	3.0	4.5	4.4	7.33	0.0	5.3	1.3
CS2	TM	27.6	30.5	30.5	3.13	0.0	0.8	1.3
CS3	FT	0.0	0.1	0.0	0.52	10.4	2.3	0.0
CS3	GMM	26.9	29.8	29.8	6.79	0.0	1.7	2.7
CS3	GMG	24.0	27.3	27.3	9.32	0.0	2.3	3.4
CS4	ET	9.1	13.0	13.0	15.24	0.0	3.7	2.7
CS4	DS	1.5	5.2	4.9	5.96	0.30	1.0	0.3
CS4	IC	7.0	11.2	11.2	6.73	0.0	1.7	1.1
E1	EN	32.1	34.2	34.2	16.44	0.0	5.7	10.7
E1	EM	26.6	28.8	28.8	10.09	0.0	3.6	5.7
E2	MR	31.7	34.1	34.1	2.92	0.0	0.9	1.7
E2	EN	30.4	32.6	32.6	19.37	0.0	6.8	12.3
E2	EM	16.7	18.7	18.7	11.37	0.0	5.1	5.3
E2	HT	36.3	38.8	38.8	14.19	0.0	3.3	7.1
S1	MA	0.0	0.0	0.0	-0.09	42.8	0.4	0.0
S1	YN	3.4	6.1	6.1	4.87	0.0	1.9	0.6
S1	PN	0.6	2.0	1.9	0.85	0.0	0.6	0.1
S1	SK	0.0	0.0	0.0	0.31	19.7	2.2	0.0
S1	DK	0.0	0.2	0.0	0.16	35.9	0.4	0.0
S1	HM	0.0	0.7	0.0	0.53	28.8	0.4	0.0
S2	MS	3.6	5.8	5.8	18.40	0.0	9.1	3.0
S2	SH	3.8	5.9	5.9	7.29	0.0	3.8	1.3
Total ship		16.1 1/	18.0 1/	18.1 1/	238.0 2/	9.2 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slack in hours divided by sum of work-center capabilities in hours. capabilities in hours.

are available on the SWL algorithm printouts. It is necessary to refer to these detailed listings to determine, for example, the precise moments and lengths of time the maximum deferral exists.

2.30 The maximum number of billets needed to eliminate deferral is also determined. This is an academic value, which will be used as an indicator of the impact of alternatives. The SWL algorithm computes the number of billets required to eliminate the cumulative deferral existing at <u>each</u> of the 10 observation points within the OPSKED. For example, the number of billets to eliminate deferral at the tenth observation point (EOC) represents the number of billets that, if added to the work center, would result in no EOC deferral. Similarly the number of billets required to have zero deferral through the first, second, and third, etc., observation points are calculated. Note that the value may be positive, indicating additional billets are required, or negative, indicating billets may be removed without creating deferral. The maximum number of billets needed to eliminate deferral is the algebraically largest number of billets required to eliminate the deferral encountered at <u>any</u> of the observation points during the OPSKED. This value can be misleading, since, depending on the selection of the observation points, it may represent the number of billets required to eliminate deferral over a very short period of time (perhaps 1 or 2 wk). In general, the maximum billets to eliminate deferral is considerably higher (on the order of 2 to 10 times) than the number of billets required to eliminate deferral at EOC, and in some cases the maximum billets to eliminate deferral is positive while the number of billets to eliminate EOC deferral is actually negative (indicating that, although the work center is usually undertasked, over the course of the OPSKED,

overtasking exists during one or more specific phases). The maximum billets to eliminate deferral is used as a measure of the peak or worst-case overtasking that is expected to occur. As such, it is useful in analyzing the impacts of alternatives. Note that the computation of this value for the total ship consists of the simple summary of the positive work-center maximum billets to eliminate deferral. As can be seen, this technique results in a large number. This number should not be interpreted as representative of the manning increase required to reduce deferral to an acceptable level; it should be used only as an indicator of the impact of alternatives.

2.31 Basal slack as a percentage of capability is also shown. Basal slack is the cumulative hours of undertasking, i.e., hours of capability in excess of required phase work load. The figures shown on the tables are the EOC basal slack expressed as a percentage of the total capability for the work center during the cycle. Note that work centers fall into one of three general categories:

- Zero Deferral, Basal Slack Present. These work centers are generally undertasked throughout the OPSKED (e.g., Work Center X PO, Table 2.12)
- Deferral and Basal Slack. These work centers are undertasked during some phases and overtasked during others (e.g., Work Center X PC in Table 2.12)
- Deferral Present, Zero Basal Slack. These work centers are overtasked during all phases of the OPSKED (e.g., Work Center X YN in Table 2.12).

2.32 Also displayed is work load as a percentage of total ship work load and EOC deferral as a percentage of total ship deferral.

The work load and EOC deferral associated with each work center is expressed as a percentage of the totals for the ship. For example, from Table 2.12 it may be seen that Work Center X YN is responsible for 1.5% of the total work load on the ship. At EOC, the same work center is expected to have deferred work amounting to 13.6% of the total deferral for the ship.

Baseline Utility

2.33 The baseline results are unique for the set of parameters selected for use in the development process. As previously shown in the FMPS and FMPS extension, significantly different results would occur if one or more alternative work-load or capability sensitivity parameters had been used. The baseline results were developed for and must be viewed in the context of their intended use: providing a reference from which the potential impact of alternative ship organizations may be observed.

Analysis of Baselines

2.34 The FMPS and FMPS extension contains detailed analyses of the shifts in slack and deferral patterns that result from changes in the various sensitivity parameters and, hence, provide insight into the causative agents producing the specific results observed in the baselines as they appear here. Redundant analyses have not bee performed during this effort. The following discussion interprets the FF-1052 and FFG-7 class baselines in the same manner in which the results of subsequent simulations (by which alternative organizations were tested) were interpreted and, therefore, facilitate the evaluation process.

2.35 FF-1052 Class Baseline. Table 2.14 displays the percentage of work centers falling into each of six cells based on the basal slack and EOC deferral associated with each work center. For example, 25.6% of the work centers on the ship have less than 3% EOC deferral and greater than 15% basal slack, 5.7% of the work centers have 3% to 10% EOC deferral and less than 5% basal slack, etc. Similarly the total columns and rows, for example, show that, overall, 71.4% of the work centers have less than 3% deferral, and 51.5% have less than 5% basal slack. The asterisks indicate the cell into which the ship as a whole falls. One measure of the impact of alternative organizations is the manner in which the percentages in each cell as well as the total for each row and column vary when compared to the baseline. For example, an alternative that results in a high percentage of work centers falling in the <3% EOC deferral/<5% basal slack cell will generally be considered to have had a favorable impact on the ship, particularly if the ship also falls within this cell.

2.36 Table 2.15 is a similar array of six cells showing the percentage of work centers with various combinations of EOC deferral and cycle deferral range (indicated by the difference between the maximum and minimum deferrals observed at the 10 cycle observation points). It can be seen that 40% of the work centers not only have <3% deferral at EOC but the deferral range throughout the cycle is small (<1%). One the other hand, of the 22.9% of the work centers that have >10% deferral at EOC, 8.6% have a significant (>5%) variation in deferral throughout the cycle. A second measure of the impact of alternative organizations is the change in variation (range) of deferrals caused by the alternative. For example, an alternative could result in <3% EOC deferral for 100% of the work centers, but if the

TABLE 2.14

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS, BASELINE

EOC Deferral, %	Percentage of Work Centers			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	22.9	22.9	25.6	71.4
3-10	5.7	*	--	5.7
>10	22.9	--	--	22.9
Total	51.5	22.9	25.6	100.0

* Ship: 5.3% EOC deferral, 12.3% basal slack.

TABLE 2.15

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL-- FF-1052 CLASS, BASELINE

Maximum Minus Minimum, %	Percentage of Work Centers			
	EOC Deferral, %			
	3	3-10	10	Total
<1	40.0	--	--	40.0
1-5	31.4	5.7*	14.3	51.4
>5	--	--	8.6	8.6
Total	71.4	5.7	22.9	

* Ship: 5.3% EOC deferral, 1.3% maximum minus minimum deferral.

maximum minus the minimum deferral for a large portion of the work centers (or the ship as a whole) is >5%, significant deferral problems could still exist at some point(s) within the OPSKED, even though at EOC the deferral is small.

2.37 Table 2.16 is a summary of the work loads and EOC deferrals (as a percentage of the total ship) that were displayed in Table 2.12. The summary is by department and is designed to give a broader picture of the manner in which work load and potential EOC deferral are spread throughout the ship. Note that the total ship work load and EOC deferral expressed in thousands of man-hours are also shown. This table allows the general nature of both the work load and potential EOC deferral to be observed and is useful in determining where the deferral is concentrated. The ratio shown in the ratio of work load as a percentage of total ship to EOC deferral as a percentage of total ship for each department and is an indicator of the concentration of the EOC deferral. A third measure of the impact of alternative organizations is the manner in which the work load and deferral are distributed throughout the ship. For example, an alternative could result in little or no change in Tables 2.14 and 2.15. However, tables similar to Tables 2.12 and 2.16 may show that significant migration of deferral among work centers and/or departments has occurred.

2.38 <u>FFG-7 Class Baseline</u>. Tables 2.17, 2.18 and 2.19 display the same information for the FFG-7 class as was described above for the FF-1052 class baseline. To allow more comprehensive comparisons to be made between the FFG-7 and FF-1052 classes, the work load and deferral for the FFG-7 have been aggregated into "FF-1052-type departments" and the results displayed in Table 2.20. The aggregation was made by simply assigning the work load and EOC deferral for a given work center in Table

TABLE 2.16

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS, BASELINE

Department	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Executive	3	14	1:4.7
Navigation/ Operations	16	5	1:0.3
Weapons/Air	29	23	1:0.8
Engineering	36	35	1:1.0
Supply/Medical	16	23	1:1.4
Total ship, thou man-hours	2,461	129	--

* Rounded to nearest integer.

TABLE 2.17

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL-- FFG-7 CLASS, BASELINE

EOC Deferral, %	Percentage of Work Centers			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	3.6	14.3	17.8	35.7
3-10	17.9	--	--	17.9
>10	46.4	*	--	46.4
Total	67.9	14.3	17.8	100.0

* Ship: 18.1% EOC deferral, 9.2% basal slack.

TABLE 2.18

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL-- FFG-7 CLASS, BASELINE

Maximum Minus Minimum Deferral, %	Percentage of Work Centers			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	28.6	--	--	28.6
1-5	77.1	17.9	46.4*	71.4
>5	--	--	--	--
Total	35.7	17.9	46.4	--

* Ship: 18.1% EOC deferral, 2.0% maximum minus minimum deferral.

TABLE 2.19

WORK LOAD AND DEFERRAL SUMMARY--FFG-7 CLASS, BASELINE

Department	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Ship Control	29	35	1:1.2
Combat Systems	27	17	1:0.6
Engineering	25	43	1:1.7
Support	19	5	1:0.3
Total ship, thou man-hours	1,607	290	--

* Rounded to nearest integer.

TABLE 2.20

WORK LOAD AND DEFERRAL SUMMARY--FFG-7 CLASS AGGREGATED BY FF-1052-TYPE DEPARTMENTS

Department	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Executive	3	1	1:0.3
Navigation/ Operations	28	8	1:0.3
Weapons/Air	26	43	1:1.7
Engineering	27	44	1:1.8
Supply/Medical	16	4	1:0.3
Total ship, thou man-hours	1,607	290	--

* Rounded to nearest integer.

2.13 to the department that work center would appear in on the FF-1052. For example, data for Work Center SC1 QM is incorporated into the Ship Control Department figures on Table 2.19 and in the Navigation/Operations Department figures on Table 2.20.

2.39 Table 2.21 compares the relative status of the two classes in the baseline condition at EOC. As can be seen, the simulation results place the FFG-7 class in a significantly less desirable posture, relative to EOC deferral, than that of the FF-1052 class.

TABLE 2.21
BASELINE COMPARISON

Item	FF-1052 Class (A)	FFG-7 Class (B)	Ratio, A:B
Manning	297	153	1:0.5
Work load, thou man-hours	2,461	1,607	1:0.7
EOC deferral, thou man-hours	129	290	1:2.2
EOC deferral as % of work load	5.3	18.1	1:3.4
% work centers < 3% EOC deferral	71.4	35.7	1:0.5
% work centers > 10% EOC deferral	22.9	46.4	1:2.0
Department with most deferral	Engineering	Engineering	--

III. ALTERNATIVE ORGANIZATIONS

3.1 The study objectives included (a) developing alternative forms of FF-1052 and FFG-7 class ship organizations that potentially will improve the organic maintenance capabilities of the ships, (b) examining the impact of recently developed improvements in facilities maintenance and preventive maintenance techniques on ships maintenance capability, and (c) evaluating the impact on residual maintenance problems (potentially existing after the notional implementation of alternatives) of moving select maintenance tasks to the IMA or depot level. This section discusses the processes and procedures used to develop, test and evaluate the alternatives referred to in the first two objectives above. The test and evaluation results appear in Sections IV and V, and the residual maintenance problems will be addressed in Section VI.

GENERAL APPROACH

3.2 The general approach to the study consisted of the following steps:

- Developing baselines as described in Section II
- Identifying general types/categories of potential alternatives
- Collecting/preparing data for use in describing/quantifying alternatives

- Simulating implementation of alternatives through the use of the ship work load (SWL) algorithm
- Evaluating the effects of the alternatives through comparisons with the baseline condition (in most cases) or with other simulations (when alternatives were tested by utilizing sequential simulations).

3.3 The general approach was a macroanalysis. Alternatives were defined, tested, and evaluated at a level of detail that could be supported by existing data, was usable in the SWL algorithm, and sufficiently supported necessary analyses.

3.4 Work loads, for example, were handled as hours per week of a given category of work. Transfer of a certain amount of FM work load from one work center to another would be described in terms of a reduction in the FM hours per week associated with one work center and a corresponding increase in another. The specific FM tasks to be transferred would not be defined precisely. Similarly, an alternative maintenance strategy would be defined in terms of the change that would occur in hours per week per work category for each work center if the strategy were implemented. The specific change in hours required to accomplish individual tasks or the exact task affected by the new strategy would not be delineated. The impact of the alternatives was observed in the general amounts and patterns of deferral existing in the output of the SWL algorithm.

3.5 The use of a macroapproach eliminated the possibility of becoming lost in a maze of details, without reducing the validity of the conclusions. As will be seen, the guidelines and methodologies used to establish, simulate and analyze alternatives were selected to ensure that necessary constraints and feasibilities were recognized and incorporated into the processes.

CONSTRUCTION OF ALTERNATIVES

3.6 The types and general nature of alternative organizations to be tested and evaluated were identified through the following:

- Analyses of the specific baseline deferral patterns generated for each class
- Study of current and previous Navy efforts associated with ship maintenance and manpower utilization
- Consideration of the general problems surrounding work-load assignments, work accomplishment, and other organizational parameters.

3.7 The results of this identification process are shown in Figure 3.1. Alternatives were classified into three general categories:

- Formal organization alternatives, including those based on current or previously considered organizations (such as the system-oriented organization used on the FFG-7 and an organization structured around an operator/maintainer division and work-center structure as tested on a DE-1052/1078 class ship) and a zero-based functionally oriented organization (developed through functional analysis).
- Alternatives based on new maintenance concepts or strategies, including those associated with shipboard maintenance accomplishment (such as new facilities maintenance and reliability-centered maintenance (RCM) concepts currently

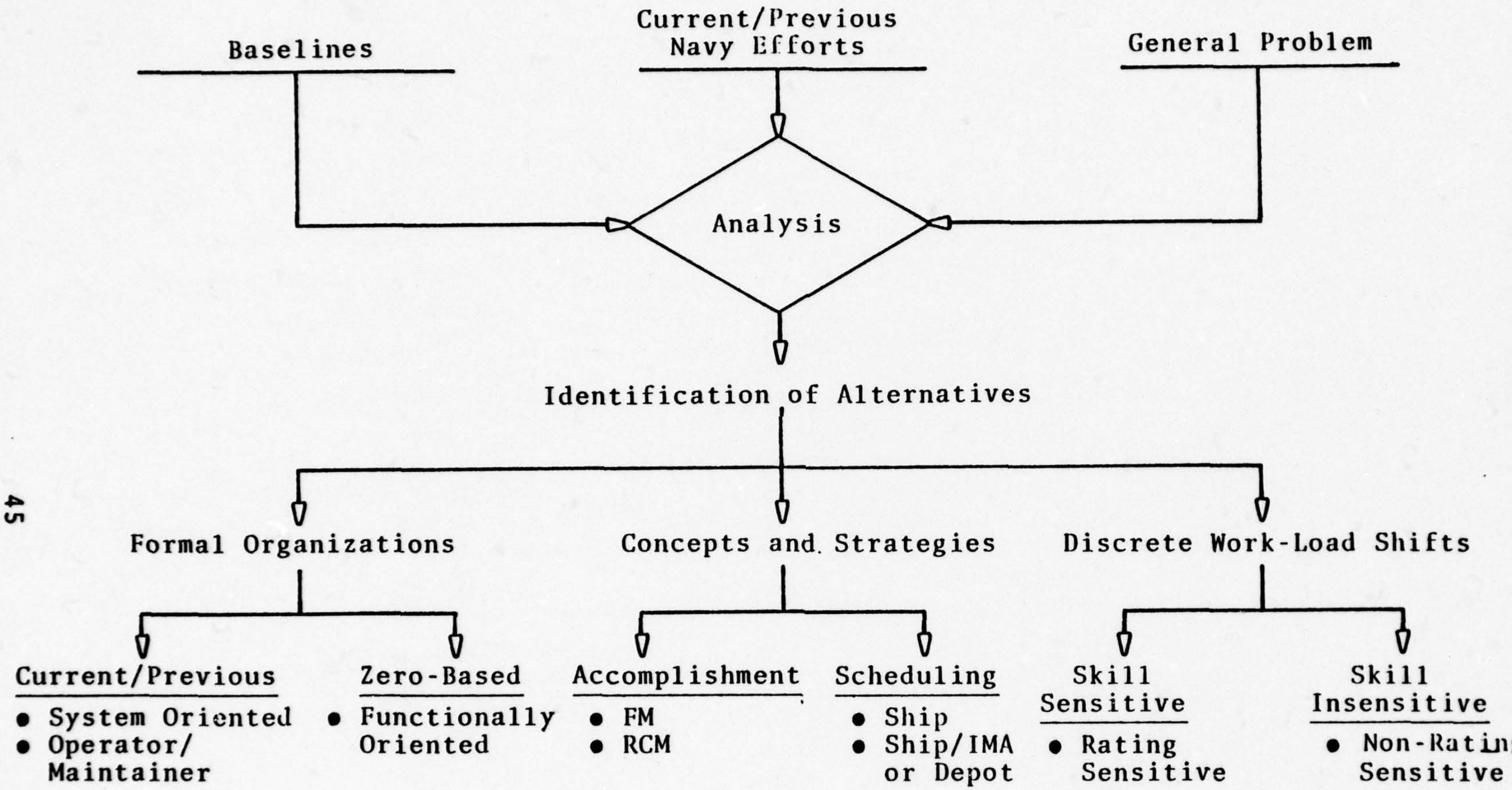

FIGURE 3.1

IDENTIFICATION AND CLASSIFICATION OF ALTERNATIVES

being investigated by the Navy) and work-load sequencing or scheduling concepts (such as those typified by the capability of the ship to schedule its own preventive maintenance through the use of the PMS system and the Navy's efforts to extend/modify overhaul cycles through the use of engineered operating cycles and the incorporation of comprehensive "work packages" into the ship/IMA and depot maintenance planning process).

- Alternatives based on discrete work-load shifts among existing work centers on the ship, including the transfer of both skill-sensitive and skill-insensitive work loads.

Specific Alternatives

3.8 The following paragraphs describe the alternative organizations developed, discuss the parametric value changes involved in defining the alternatives, and state the conventions used and data-base procedures followed in translating the alternatives into a form suitable for simulation.

3.9 Alternative 1--Work-Load Transfers. The objective was to evaluate the impact of the transfer of discrete blocks of work load among work centers. The underlying assumptions were that the process by which work load is assigned to work centers is flexible enough to allow certain amounts and types of work to be shifted from one work center to another if a more efficient/effective utilization of capability will result and that, as long as certain constraints were met, skill-sensitive (i.e., a specific rate or rating required to accomplish) as well as skill-insensitive (i.e., no specific rate or rating required to accomplish) work loads were candidates for transfer.

3.10 General Method. The work centers for which it was desirable to reduce the work load, the work centers that could accommodate an increase in work load, and the specific categories and amounts of work load that could be transferred were identified as follows:

a. The output of the SWL algorithm simulation of the reference (normally the baseline) condition was analyzed to determine the specific work centers that exhibited significant end-of-cycle (EOC) deferral. Similarly, those work centers with excess capability (i.e., little or no deferral and significant basal slack) were identified.

b. The amount of each category (OPMAN, PM, CM, FM, UT and A/S) of work load and the manning levels (by rate and rating) assigned to each work center exhibiting significant EOC deferral were analyzed to determine the nature (i.e., skill sensitivity) of the work.

c. Blocks of work load (hours per week) were identified as candidates for transfer out of the overtasked work centers. An iterative process was used to locate the receiving work center (from among those work centers that were undertasked) for each block of work load to be transferred.

d. The resultant solution was translated into SWL algorithm input by modifying the reference work loads for both the work centers from which work was transferred as well as the work centers that received the transferred work. Audit trails were maintained to ensure that work load was neither created nor eliminated during the process.

3.11 Specific Guidelines. The specific guidelines and constraints used in constructing the work-load transfer alternatives were the following:

a. The receiving work center must be able to absorb the increase in work load without significant deferral occurring in the work center during the peacetime operating cycle.

b. The receiving work center must have sufficient personnel of the proper rate to accomplish the additional work. For example, if FM is transferred to a work center, the work center must have sufficient E-4s and below to accomplish the additional work.

c. Non-rating-sensitive work load will be transferred first. If significant deferral will still exist, rating-sensitive work load may be transferred.

d. Whenever possible, the amount (hours per week) of work load transferred will be constant for all conditions and phases. For example, transfer of certain FM responsibilities during in-port phases only is less desirable than transfer of the responsibilities during all (in-port and at-sea) phases.

3.12 Classification of Work Load. The general rules used to determine the skill sensitivity of work load and, hence, the desirability and feasibility of transferring various amounts of different categories of work were:

a. FM was treated as non-rating-sensitive. However, it was generally considered to be rate and apprenticeship sensitive (i.e., the work center to

which it was transferred would have to possess sufficient E-4s and below to accomplish the additional FM, and the career pattern for the rating in the receiving work center would have to include the same apprenticeship training as found in the career pattern for the rating in the work center from which the FM was transferred).

b. Up to 50% of the UT was considered to be non-rating-sensitive. [1]

c. A/S was considered to be either rating sensitive or associated with other work loads and, hence, in general, was not transferred. The major exception to this policy occurred for YN work centers. For example, on the FF-1052 class, Work Center X YN demonstrated significant EOC deferral under baseline conditions. Certain amounts of A/S were considered for transfer to Work Centers D1 YN and A YN, since both demonstrated the capability to accomplish additional work in the baseline condition.

d. Certain OPMAN requirements were considered to be non-rating-sensitive. Specifically, most SN/FN watches in Conditions III and IV and those Condition V watches assigned to two or more ratings in the source SMDS (e.g., quarterdeck watches, sentry stations, etc.) were considered non-rating-sensitive. Such watches were classified as requiring POC/PO1, PO2/PO3, SN or FN watchstanders and were treated as transferable to any work center with the appropriate rate available to stand the watch.

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[1] Note that for the FF-1052 class, baseline data provided only a single OUS figure for each work center for each readiness condition. OUS for the FF-1052 class was broken down into UT and A/S using SMD backup data as described in Appendix C.

e. Certain PM hours were treated as non-rating-sensitive. Appendix D of the source SMDs showed a certain number of weekly hours for each work center as assignable to any PO2, PO3, SN or FN with no NEC. The hours were transferable to any work center having the appropriate rate.

f. Certain PM hours were treated as rating sensitive but transferable to certain alternative work centers. The maintenance index pages (MIPs) associated with each work center indicate, in certain instances, that more than one rating is capable of performing certain PM tasks. The weekly hours associated with such tasks were considered as transferable to the other rating(s) capable of accomplishing the task. The CM hours associated with the specific PM thus identified for transfer would also be considered transferable.

g. Certain OPMAN requirements, particularly those related to watches assigned to two ratings within the same occupational field in the source SMDS (e.g., EOOW on the FF-1052 class) were treated as rating sensitive but transferable to select alternative ratings.

3.13 Order of Work-Load Transfer. Transfers were first attempted between work centers in the same division, then, if necessary, within the same department but different division and, finally, if the first two options would not satisfactorily reduce the expected deferral, between work centers in different departments. In addition, the general order in which work load was considered for transfer was the following:

- First, non-rating-sensitive work load:
  - FM
  - OPMAN
  - UT
  - PM
- Second, rating-sensitive work load:
  - OPMAN
  - PM/CM.

3.14 Sensitivity Parameters. In translating Alternative 1 into resultant changes in the sensitivity parameters used with the SWL algorithm, only one parameter was affected: work load. The specific work-load changes involved in each simulation that dealt with Alternative 1 are shown in the appropriate portions of Sections IV and V. All other sensitivity parameters (e.g., manning, OPSKED, capability detractors, etc.) experience no change for the purposes of simulating Alternative 1.

3.15 Alternative 2--New FM Concepts. The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) is currently undertaking a project to devise, demonstrate and evaluate methods of reducing shipboard FM man-hour expenditures while improving the condition, cleanliness and appearance of shipboard spaces. Appendix D contains two documents that describe this project in some detail.

3.16 For constructing an alternative organization for testing within the scope of this report, the major facets of the DTNSRDC project are:

- Shipboard FM will be accomplished by one or more FM teams
- Special training will be given to FM team members
- Improved equipment, materials, training and management will result in the man-hours required for shipboard accomplishment of FM to be significantly reduced.

3.17 Sensitivity Parameters. Translation of these concepts into resultant changes in the sensitivity parameters used with the SWL algorithm was accomplished as follows. First work centers were considered. The number of work centers was expanded to include FM teams. The DTNSRDC project has not reached the point yet where the exact number or composition of FM teams to be used on a ship can be specified. For Alternative 2, several teams (generally corresponding to one team per major department) were constructed. These teams were designated FM1 SN, FM2 FN, FM3 SN, etc., where the FM1, FM2 and so forth indicate the team number and SN/FN indicates the apprenticeship associated with the team.

3.18 Secondly, manning was treated. The total manning for the ship was held constant at the baseline (SMD Condition III) level. Several options existed for specifying individual work-center manning levels in light of the new FM teams. The major options were as follows:

a. Calculate the manning required for each FM team based on the work load assigned to each team; reduce the manning for other work centers on the ship, where the reduction in manning for each work center would represent some prorated

value based on the relative amount of FM transferred from the work center to an FM team. This option would result in no deferral for the FM teams but would not necessarily improve (and in some cases would aggravate) the deferral problems in the remaining work centers (since fractional shifts in manning levels could not occur).

b. Reduce the manning level in work centers that would no longer be performing FM to that level that would produce zero deferral and use the resultant total reduction to man the FM teams. Since some work centers would have EOC deferral even with all their FM transferred to an FM team, the aggregate reduction would not provide sufficient manning for the FM teams, and significant FM team deferral would result.

c. Reduce the manning level for work centers that would no longer be accomplishing FM, where such a reduction would be based on the prorated amount of FM transferred to an FM team, but limit the reduction to that which could cause no increase in deferral for the work center. For example, if a work center has an initial manning level of five and an EOC deferral of 20%, the transfer of the work center's FM to an FM team might indicate that two billets should also be transferred, based on the amount of FM transferred. However, the original work center's deferral might rise to 30% if the work-center manning were reduced to three. On the other hand, 5% deferral might remain if the work-center manning reduction was limited to one,

or 0% EOC deferral (but significant slack) might occur if the work-center manning was held at five. In such a case, the work-center manning would be set at four, releasing one billet to the FM team while simultaneously reducing the deferral for the work center. In conjunction with this procedure, the manning of all work centers would be reviewed to determine which work centers could sustain a manning decrement below that indicated by the prorated amount of FM transferred to an FM team. For example, a work center might have only a very small amount of FM assigned; hence, the transfer of the FM to an FM team would indicate that no change in the work-center manning (based on the reduction in work load) was warranted. Nevertheless, the slack and deferral pattern for the work center might indicate that one (or more) billets could be shifted out of the work center without causing additional deferral, particularly if the work center were undertasked to begin with. In such a case, the manning of the work center would be decreased and FM team manning increased by a corresponding amount. The net effect would be to minimize the effects of FM team formation on original work centers while providing a reasonable manning level for the FM teams. Note that FM team manning would still not necessarily be sufficient to accomplish all assigned work. In addition, certain nonquantifiable problems may arise, since a work center that transfers a significant amount of FM to an FM team may not be required to suffer a manning decrement, while a work center that transfers little or no FM to an FM team may suffer a manning reduction.

In general, the third option was used in determining the manning shifts required to simulate the construction of FM teams. This option minimizes the impact on other work centers and allows for most (but not necessarily all) of the FM teams' work load to be accomplished.

3.19 The formal organization was also considered in this analysis. FM teams were constructed as separate work centers and given discrete division designations. They were assigned to the departments in which the bulk of their work load originally resided.

3.20 Work loads were then established. The FM work load for non-FM team work centers was set at 0. The only exception to this rule appears in the HM work center, which retained its original FM. It is not clear whether or not all or part of the HM FM work load would eventually be covered by the DTNSRDC project concepts, but the assumption that HMs would still perform the bulk of their own FM appears reasonable and therefore was used in constructing Alternative 2. FM team work load was established as follows:

a. For each FM team the total FM work load (hours per week) previously assigned to the work centers in the department(s) now covered by the FM team was assigned to the FM team. This work load was subsequently reduced by 30%. The 30% reduction reflects a conservative estimate of the expected decrease in FM man-hours required when the DTNSRDC project results are fully implemented. The specific figure of 30% was arrived at in concert with DTNSRDC estimates, which in turn were based on

initial project results, including those that demonstrated an actual 42% reduction in a limited shipboard test (see Appendix D).

b. In two simulations (one for each class ship), the work load for the FM teams consisted solely of FM. In other simulations, Alternative 2 was used in conjunction with several other alternatives (e.g., discrete work-load transfers, modified formal organizations, etc.), and the basic (FM) work-load of the FM teams was augmented by additional categories of work. The amount and nature of this additional work were arrived at by superimposing the additional alternatives on top of Alternative 2.

3.21 The construction of FM teams required that the capability detractors associated with the teams be identified. The following rationale was applied to develop FM team capability detractors:

a. Service diversions (hours per billet per week) applied to FM team members were the same as those used in the baseline (OPNAV 10P-23 values)

b. UA and TAD (hours per billet per week) values were the same as those used in the baseline (FMPS average values)

c. Leave factors (hours per billet per week) were computed in the same manner as used in the baseline leave factor computations: FMPS average values (at sea) and FMPS average values modified to reflect the LVUPK intense leave period in port. Note that the LVUPK phase

leave factor assigned to each FM team is sensitive to the training option used. The specific leave factors used with each simulation are displayed (along with the other simulation unique data) in Sections IV and V.

d. Interim DTNSRDC project results indicate that approximately 0.125 hr/wk of FM-related shipboard training will be required of each FM team member. This value was arrived at by assuming that the 13 training modules referred to in Appendix D are approximately 30 min long and would be reviewed by each FM team member once every year: (13 x 0.5 hr)/52 wk = 0.125 hr/wk. Two major options existed relative to FM team work-center training beyond that prescribed by the DTNSRDC project:

   1. Treat the 0.125 hr/wk per FM team member as the total training required for the FM teams. This option would clearly apply only if the FM teams were assigned no other category of work and FM team members were not expected to strike for a rating during the period they were assigned to an FM team.

   2. Assume that a pro-rata share of the training originally assigned to the work centers from which billets would be taken to form the FM teams would be transferred to the FM team. This option would be reasonable if the FM teams were assigned work other than FM and/or the FM team members were considered to be only temporarily assigned to FM duties and would eventually be expected

to rotate back to their original work center. In such a case, rating-related training would be continued by FM team members.

Both training options were used in conjunction with simulations incorporating Alternative 2. For each simulation discussed in Sections IV and V, if Alternative 2 were included in the simulation, the FM team-training option used is identified.

3.22 OPSKED and work and productive allowances remain unchanged for the simulation of Alternative 2.

3.23 Alternative 3--Reliability-Centered Maintenance (RCM) Concepts. A new preventive maintenance logic, RCM, has been successfully developed and implemented for use relative to both commercial and naval aircraft maintenance. Significant reductions in required maintenance effort have been achieved, with substantial increases in operational availability also occurring through the use of this logic. As part of the Maintenance System Development Plan (MSDP) within the Ship Support Improvement Project (SSIP), a methodology for determining scheduled maintenance tasks and resources for ships using RCM concepts are being developed. The construction of Alternative 3 centers on the translation of the anticipated results of the SSIP RCM effort into the changes in SWL algorithm sensitivity parameters required to describe the new concept.

3.24 Assumptions. The following assumptions were made in constructing Alternative 3:

- When applied to ships, RCM logic will result in the same relative decrease in scheduled maintenance (i.e., PM) as has been experienced when the logic is applied to naval aircraft. Specifically, the decrease in PM expected to result due to RCM concepts is 37.9%, based on P-3 aircraft Improved Maintenance Program (IMP) test results.
- RCM concepts will require no change in work-center training requirements.
- Unscheduled maintenance (i.e., CM) requirements (hours per week) will be unchanged due to RCM implementation. This assumption is consistent with IMP test results.

3.25 Sensitivity Parameters. With the above assumptions, the only sensitivity parameter requiring modification to describe fully Alternative 3 is work load, specifically PM (hours per week). For simulations in which Alternative 3 is incorporated, individual work-center PM work loads have been reduced to 0.621 of their original values. No other sensitivity parameter is changed for the reflection of Alternative 3 in the simulations.

3.26 <u>Alternative 4--Work Packages</u>. The maintenance strategies for both the FF-1052 and FFG-7 classes will be indicated, in part, in the operational schedules (OPSKEDs) for the classes. As discussed in Section II, the OPSKEDs developed for use in this study incorporate phases that correspond to the intense maintenance periods planned for each class. While the OPSKEDs reflect phases during which intermediate maintenance activity (IMA) or depot-level work will be accomplished, the baseline work loads for each work center are constant for each in-port phase. The development of Alternative 4, therefore, centers

on the identification of the manner in which the baseline work loads must be adjusted to reflect the class maintenance strategy and the quantification of the adjustments in terms of changes in the SWL algorithm sensitivity parameters.

3.27 One way in which the FF-1052 and FFG-7 class maintenance strategies will manifest themselves is through the work packages being developed for each class. These packages will define the tasks (and related effort) to be accomplished by the ship's force as well as the IMA or depot during specific maintenance availabilities. Although interim work packages have been developed for both classes, final packages have not been produced. In addition, the format of the packages is not amenable to direct use with the SWL algorithm. Accordingly, notional work packages have been developed for use in this study. Appendix E contains a detailed discussion of the procedures followed to develop the work packages; however, a general description of the work packages is given in the following paragraphs.

3.28 The notional work packages take the form of two sets of numbers for each work center. The first set represents the amount (hours per week) of the work center's work-package work load scheduled for accomplishment during each maintenance period. For example, there are six intermediate maintenance availabilities (IMAVs) and two selected restricted availabilities (SRAs) associated with the FFG-7 class baseline OPSKED. The notional work-package work loads for each work center would take the form of a table in which, for each work center, the work-package work load for each category of work (normally PM, CM, and OUS (specifically UT)) for each maintenance period would be displayed.

3.29 The second set of numbers associated with each work center represents the amounts (hours per week) by which the average

weekly work loads for each work center must be reduced as a result of the work packages. The majority of the work specified for accomplishment in the work package arises from existing PMS requirements, and, hence, the baseline average weekly PM and CM work loads (hours per week) associated with each work center include the times associated with the tasks now specified for accomplishment during a set period (IMAV or SRA). To avoid double accounting, the baseline average weekly work loads must be reduced by an amount equal to the hours per week of PMS work load specified for accomplishment during an IMAV or SRA.

3.30 Sensitivity Parameters. Changes in two sensitivity parameters are required to describe the notional work packages in a manner suitable for SWL algorithm use. First, the baseline work loads are modified to reflect the change in average weekly hours of PM and CM required as a result of the work packages. Second, work-load variances are developed for use in simulating the maintenance-phase work loads for each work center. For example, if a work-center baseline PM average weekly work load is 50.19 hr/wk and the total PM work-package work load for the work center is 10.00 hr/wk for IMAV-1 and 5.00 hr/wk for IMAV-2, the sensitivity parameters would change as follows (assuming that all of the work-package PM was originally included in the 50.19 hr/wk average weekly PM work load): since each IMAV is of 3-wk duration, the work package represents a total of 45 hr ((3 x 10) + (3 x 5)) of PM. This amount of work load was originally included in the 50.19 hr/wk of PM associated with the work center. Over a 234-wk schedule, the 45 hr represent 0.19 hr/wk. The new PM average weekly work load for the work center (in hours per week) is, therefore, 50.19 - 0.19 = 50.00. During IMAV-1, the PM work load is 50.00 hr/wk (average weekly PM work load) plus 10 hr/wk (work-package PM work load), or

60.00 hr/wk. For IMAV-2, the PM work load is 55.00 hr/wk. For the SWL algorithm, the variations in PM work load occuring during IMAV-1 and IMAV-2 would be described by using work-load variances. The work-load variances are simply factors associated with each phase in the OPSKED that reflects the difference (for each work-load category) between the phase work load and the average weekly work load. The PM work-load variances associated with IMAV-1 and IMAV-2 in the example would be +0.2 and +0.1, respectively, indicating that the IMAV-1 PM work load was (1 + 0.2) x 50.00 hr/wk and that the IMAV-2 PM work load was (1 + 0.1) x 50.00 hr/wk.

3.31 Alternative 5--Shipboard Scheduling. Alternative 2, discrete work-load transfers, centered on the transfer of work from an overtasked work center to an undertasked work center. In some cases, however, a specific work center may be overtasked during certain phases yet undertasked during other periods. Similarly, a generally overtasked or undertasked work center may not be overtasked or undertasked to the same degree during all phases. A portion of the SWL algorithm output shows the degree of overtasking or undertasking expected for each work center for each phase relative to both the basic work load associated with the phase as well as the phase total work load (basic work load plus deferral carried over into the phase from preceding phases). It is possible, therefore, to construct an alternative centering on the shifting of work load, not from work center to work center, but from phase to phase, with the original work center retaining responsibility for accomplishment. Such shifts, collectively described by the term shipboard scheduling, form the basis for Alternative 5.

3.32 A certain amount of shipboard scheduling occurs in the fleet today. As part of the planned maintenance system (PMS),

daily, weekly, monthly, quarterly, and cycle schedules are used at the work-center, division, and department level in an attempt to ensure that PM tasks are performed with the proper periodicity and, to some extent, efficiently (since, if possible, tasks that can be performed simultaneously or in a lock-step sequence with other tasks are to be scheduled together). In addition, the ship's operational schedule is used to assist in the scheduling of conditionally or situationally dependent PM.

3.33 Alternative 5 extends the type of scheduling principles used in the PMS system to all work loads on the ship with the exception of OPMAN. The following general assumptions were used to construct the alternative:

- A significant portion of the work load in each work category (PM, CM, FM, OUS (UT and A/S)) is "schedulable" in the sense that it may be accomplished during any phase of the OPSKED and that the time of accomplishment is within the control of the work center.
- In general, the "schedulable" portion of each work category would not exceed 50% of the reference (normally the baseline) average weekly work load for each work center.

Implicit to these assumptions are the statements that all CM does not have to be performed on an as-occurring basis and that, in the case of work centers with large amounts of evolution-associated UT, the chain of command would be responsive to scheduling requests based on the objective of maximizing the ability of work centers to accomplish all required work.

3.34 The following step-by-step procedure was used to determine the work-load scheduling to be simulated:

a. The total capability was computed for each work center over the operational cycle and compared to the total work load for the work center over the cycle. The average weekly deferral (if work load exceeded capability) or slack (if capability exceeded work load) was calculated.

b. For each phase, the weekly deferral or slack was computed based on the capability existing during the phase and the work load (excluding deferral carried over from the previous phases) for the phase.

c. The average weekly deferral or slack calculated for the cycle was compared to the weekly deferral or slack present in each phase. In this manner, the total amount of work load to be scheduled into or out of each phase to bring the phase's weekly deferral or slack up or down to the cycle average was determined. Since no work load is actually added to or subtracted from the total cycle work load for the work center, phases fall into two groups, one group from which work load had to be removed and one group into which work load could be scheduled, where the total hours of work load to be scheduled out of the first group equaled the total hours to be scheduled into the second group.

d. The amount of each category of work to be scheduled from one phase to another was determined based on the total work load to be scheduled out of the phase and the amount of work load necessary to bring another phase up to the average weekly deferral/slack level. In general, work load scheduled out of a phase falling in the first group discussed above would be scheduled evenly into all phases in the second group.

3.35 Sensitivity Parameters. The only sensitivity parameter affected by Alternative 5 was work-load variances. For example, if a work center had an average weekly slack over the entire OPSKED of 2 man-hours per week; one phase, of 4 wk duration, had deferral of 75 man-hours/wk; and all other phases (totaling 230 wk) had slack of 3.34 man-hours/wk, work-load variances would be constructed as follows:

a. To change the condition of the phase with 75 man-hours/wk of deferral to the average weekly slack condition, 77 man-hours/wk of work must be scheduled out of the phase. If the original work load for the phase, excluding OPMAN, consisted of 200 man-hours/wk of PM, 200 man-hours/wk of CM, 300 man-hours/wk of FM and 250 man-hours/wk of OUS, the work load to be scheduled out of the phase could be chosen as: 40 man-hours/wk of FM, +30 man-hours/wk of OUS and +7 man-hours/wk of PM, for a total of 77 man-hours/wk. The work-load variances for the phase would then be $-7/200 = -0.035$ for PM, $-30/250 = -0.12$ for OUS and $-40/300 = -0.133$ for FM. The work load would be scheduled evenly into all other

phases. The total FM to be scheduled into the other phases would be

$$40 \text{ man-hours/wk} \times 4 \text{ wk} = 160 \text{ man-hours}$$

or, dividing by the remaining 230 wk in the cycle, 0.70 man-hours/wk. If the original FM for all other phases were constant at 300 man-hours/wk, the FM work-load variance for all other phases would be

$$+0.70/300 = +0.002.$$

Similarly, PM and OUS variances could be calculated for the other phases. Note that the total work load transferred into the other phases (0.70 man-hours/wk FM; 28/230, or 0.12 man-hours/wk, of PM and 120/230, or 0.52 man-hours/wk, of OUS for a total of 1.34 man-hours/wk of additional work load) would reduce the slack in all other phases from 3.34 man-hours/wk to 2.00 man-hours/wk. At this point, all phases would show 2.00 man-hours/wk slack, the average weekly slack over the entire OPSKED.

3.36 Alternative 6--Formal Organizational/Concepts. The formal organization of a ship defines boundaries around the responsibilities of the various work centers, divisions and departments into which the ship is divided. These boundaries, in turn, determine not only the span of managerial control available to the division officers and department heads but may also affect the ability of the ship to accomplish all work. Alternative 6 was constructed to evaluate the impact on the organic maintenance capability of the FF-1052 class of formal organizations that have been defined previously and/or tested by the Navy. The specific initiatives around which Alternative 6 was constructed were as follows:

a. FFG-7 Combat Systems Concept. Within this concept, all CIC, weapons, and operations functions are placed under a single combat systems officer, with the objective of reducing problems associated with the divisional/departmental barriers that traditionally separate these functions.

b. Operator/Maintainer Organization. During the period 1 July to 30 November 1972, a trial reorganization of a destroyer engineering department was conducted by CRUDESLANT. The results of the trial [2/] indicated that an organization based on two distinct groups, one primarily responsible for maintenance and the other handling necessary watchstanding requirements, could potentially result in a more economical utilization of manpower, while simultaneously providing an improvement in the quality of maintenance work performed.

3.37 The steps described in the following paragraphs were used to construct an FF-1052 class organization based on a combination of the FFG-7 combat systems concept and an operator/maintainer organization concept. Based on assigned work loads, nature of work, rating included, and relative manning level, each work center in the FF-1052 class baseline was "linked" with its equivalent work center on the FFG-7. For example, FF-1052 class Work Centers OC RM, OI EW and R HT were "linked" to FFG-7 class baseline Work Centers SC2 RM, CS1 EW, and E2 HT. In general, each FF-1052 class work center was "linked" to a single FFG-7 class work center and vice versa; however, exceptions existed as follows:

[2/] Results were reported in a letter from the Commanding Officer, USS ELMER MONTGOMERY (DE-1082), DE-1082/RSS:a1, 5400 ser 151, 3 May 1973.

- FF-1052 Work Center X PO had no equivalent on the FFG-7; therefore, the "link" was established with a notional Work Center S1 PO.
- FF-1052 Work Centers X YN, D1 YN, and A YN all were linked with S1 YN on the FFG-7.
- FFG-7 Work Center SC1 QM was linked to Work Center N QM on the FF-1052 as well as a portion of D1 BM (consisting of the SN and their associated work load).
- Work Center SC3 BM on the FFG-7 was linked to Work Centers D1 BM (minus the SN in D1 BM) and AD SN on the FF-1052.
- Work Center OE ET on the FF-1052 was linked to both Work Center CS4 ET and a notional work center, SC2 ET, on the FFG-7.
- Work Centers S2 MS and S5 MS on the FF-1052 were both linked to Work Center S2 MS on the FFG-7.
- Work Centers A MM and M MM were, primarily as a matter of convenience in anticipation of subsequent steps, linked to a notional Work Center E1 MM on the FFG-7.

3.38 Using the links established above as a guide, the FF-1052 class baseline organization was notionally transformed into an FFG-7-equivalent-type organization by replacing the original (FF-1052) work-center designators with the designator of the FFG-7 work centers (e.g., OI EW to CS1 EW; X YN, D1 YN and A YN all to S1 YN; etc.). Where an FF-1052 work center was linked to two FFG-7 work centers, the FF-1052 work center was first split into two parts and then new designators assigned (e.g., D1 BM was split into D1 BM (minus SN) and D1 BM (SN) and subsequently redesignated SC3 BM and SC1 QM). The split was based

on the proportion of work load linked to each FFG-7 work center and was made by dividing the work load itself (based on the link established between the FF-1052 work center and FFG-7 work centers), prorating the manning (based on the work-load split) and prorating the training (based on the manning split). Work centers that now had the same designators were merged into a single work center by summing the manning, work loads and training requirements (e.g., a single S1 YN was formed by merging the three S1 YNs resulting from the redesignation of Work Centers X YN, D1 YN, and A YN).

3.39 The operator/maintainer concepts tested on the USS ELMER MONTGOMERY were applied to the FFG-7-equivalent-type FF-1052 organization by:

- Notionally merging the Engineering Department E1 EM and E2 EM work centers and E1 EN and E2 EN work centers into one EM and one EN work center.
- Splitting each Engineering Department work center into an operator work center (to which all OPMAN work load and a pro-rata amount of FM and OUS work loads and training were assigned) and a maintenance work center (to which all PM and CM and a pro-rata amount of FM, OUS and training were assigned).
- Placing the engineering operator work centers in a single division (E1) and the maintenance work centers in a separate division (E2).
- Organizing the combat systems work centers into two divisions: CS1 (including ET, EW, OS and STG work centers) and CS2 (including TM, FTG, FTM, GMG, and GMT work centers) based on the

Condition IV OPMAN work load associated with each work center. (CS2 work centers had no Condition IV OPMAN work load.)

3.40 Table 3.1 displays the resultant work centers along with the manning level set for each, identification of the source (baseline) work centers from which the new work centers arose, and a brief statement as to the work loads associated with each new work center. Note that, although the IC work center was placed in the Combat Systems Department on the FFG-7, the Alternative 6 IC work centers have been left in the Engineering Department, based on feedback obtained from the FFG-7 Engineering Officer, which indicated that certain morale problems had arisen from the placement of IC personnel in a nonengineering department.

3.41 Sensitivity Parameters. The sensitivity parameters affected by Alternative 6 are the work centers, work-center manning and work loads (as described above), as well as training (due to the new manning breakouts) and leave (during LVUPK, due to the new training breakout). The values for the new training and leave during LVUPK are shown in Section IV, along with the results of the simulation in which Alternative 6 was tested. The other SWL algorithm sensitivity parameters (e.g., workweek, service diversions, leave during normal in-port and at-sea phases) are not affected by Alternative 6.

3.42 <u>Alternative 7--Functionally Based Formal Organization</u>. The combat systems and operator/maintainer concepts used to construct an FF-1052 class formal organization in Alternative 6 represent two types of functionally oriented organizations. The first is based on an aggregation of functions according to the <u>systems</u> associated with the functions. The second is

TABLE 3.1
FF-1052 ORGANIZATION--ALTERNATIVE 6

New Work Centers			Manning	Source Work Center/Work Load
Department	Division	Rating		
Ship control	SC1	QM	26	N QM (5 billets), D1 BM (21 billets); original N QM work load plus work load originally associated with 21 D1 BM seaman billets
	SC1	SM	6	OL SM; work load same as original work center
	SC2	ET	3	OE ET (3 billets); ETN work load
	SC2	RM	13	OL RM; work load same as original work center
	SC3	BM	16	D1 BM (14 billets), AD SN (2 billets); non-SN D1 BM work load plus AD SN work load
Combat systems	CS1	ET	3	OE ET (3 billets); ETR work load
	CS1	EW	7	OI EW; work load same as original work center
	CS1	OS	29	OI OS; work load same as original work center
	CS1	STG	19	F2 STG; work load same as original work center
	CS2	FTG	6	F FTG; work load same as original work center (no OPMAN)
	CS2	FTM	7	F1 FTM; work load same as original work center (no OPMAN)
	CS2	GMG	8	D2 GMG; work load same as original work center (no OPMAN)
	CS2	GMT	7	F2 GMT; work load same as original work center (no OPMAN)
	CS2	TM	2	F2 TM; work load same as original work center (no OPMAN)
Engineering	E1	BT	23	B BT (23 billets); all BT OPMAN; prorated amount of FM, OUS; no PM or CM
	E1	EM	3	E EM (3 billets); all EM OPMAN; prorated amount of FM, OUS; no PM or CM
	E1	HT	6	R HT (6 billets); all HT OPMAN; prorated amount of FM, OUS; no PM or CM
	E1	IC	3	E IC (3 billets); all IC OPMAN; prorated amount of FM, OUS; no PM or CM
	E1	MM	23	A MM (3 billets), M MM (20 billets); all MM OPMAN; prorated amount of FM, OUS; no PM or CM
	E2	BT	8	B BT (8 billets); all BT PM and CM; prorated amount of FM, OUS; no OPMAN
	E2	EM	4	E EM (4 billets); all EM PM and CM; prorated amount of FM, OUS; no OPMAN
	E2	EN	2	A EN; work load same as original work center (no OPMAN)
	E2	HT	8	R HT (8 billets); all HT PM and CM; prorated amount of FM, OUS: no OPMAN
	E2	IC	2	E IC (2 billets); all IC PM and CM; prorated amount of FM, OUS; no OPMAN
	E2	MM	10	A MM (3 billets), M MM (7 billets); all MM PM and CM; prorated amount of FM and OUS; no OPMAN
	E2	MR	1	A MR; work load same as original work center (no OPMAN)
Support	S1	DK	2	S4 DK; work load same as original work center
	S1	HM	2	H HM; work load same as original work center
	S1	MA	1	X MA; work load same as original work center
	S1	PC	1	X PC; work load same as original work center
	S1	PO	1	X PO; work load same as original work center
	S1	PN	3	X PN; work load same as original work center
	S1	SK	7	S1 SK; work load same as original work center
	S1	YN	4	X YN (2 billets); D1 YN (1 billet); work load sum of original work centers
	S2	MS	26	S2 MS (18 billets), S5 MS (8 billets); work load same as sum of original work centers
	S2	SH	5	S3 SH; work load same as original work center
Total	--	--	297	--

based on an aggregation of functions according to the nature of the work associated with the functions. Alternative 7 was constructed through a general application of functional analysis principles to the FF-1052 class. The objective was to develop a new formal organization based on logical functional aggregations, where the precise logic to be used in aggregating functions is left to the discretion of the analyst.

3.43 The first step in the analysis was to develop a means to identify, classify and display functions so that their interrelationships could be observed. The general framework used to accomplish this step was based on an adaptation of the work-unit analysis technology developed by Dr. Marvin E. Mundel. [3/] The hierarchical structuring principles used in the methodology were readily adaptable to the situation in which the work was specified (rather than measured) and the objective was to determine the functional relationships present. Figure 3.2 is an example of the typical functional hierarchy resulting from the use of an adaptation of the work-unit analysis technology.

3.44 Having determined the framework in which the functional analysis would be performed, the following steps were accomplished:

a. FF-1052 baseline source material was reviewed and reference made to additional documents such as NAVPERS 18068D [4/] for additional clarification of work performed and qualifications/capabilities of various rates, ratings and NEC holders and to the Navy Enlisted Occupational Classification

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3/ M. E. Mundel, Measuring and Enhancing the Productivity of Service and Government Organizations, the Asian Productivity Organization, Tokyo, Japan, 1975.

4/ Bureau of Naval Personnel (NAVPERS), The Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068D Series.

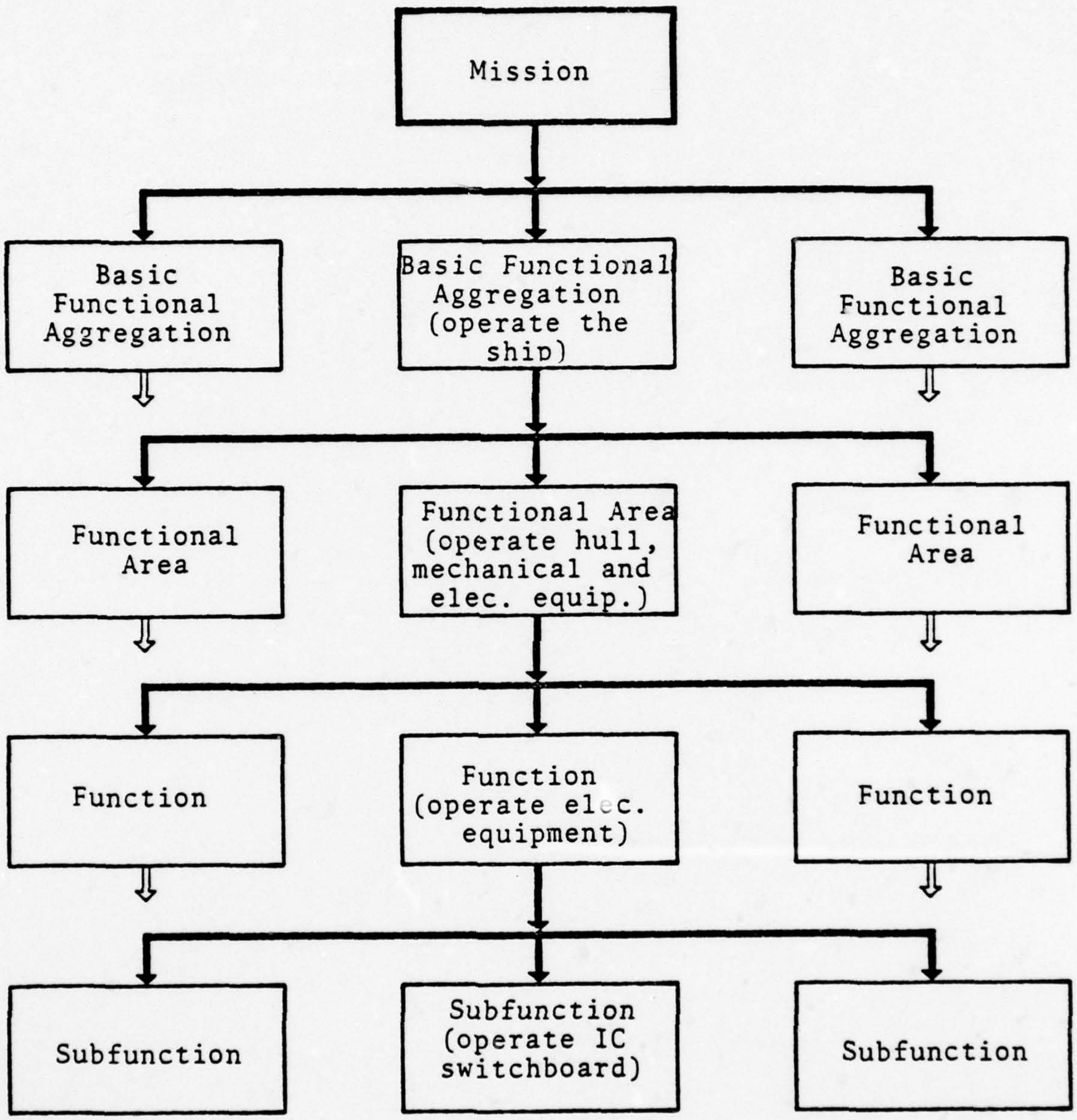

FIGURE 3.2
TYPICAL FUNCTIONAL HIERARCHY

System (NEOCS) Study [5] for additional information concerning possible future changes relative to occupation fields and rating composition.

b. The work load associated with the FF-1052 class was broken down into an array similar to that shown in Figure 3.2. The objective of this step was to describe and display the various functions, subfunctions, basic functional aggregations and relative functional areas existing on the ship in an initial hierarchical display based on the groupings present in the current FF-1052 class organization.

c. The initial array was analyzed and new groupings formed based on alternative logics. For example, in the initial array, a subfunctional grouping consisting of all the OPMAN, PM, CM, OUS, and FM performed by MMs in the machinery (M) division existed. Under the new array, the M MM OPMAN was placed in a subfunctional grouping that included B BT and A MM OPMAN (i.e., main propulsion and auxiliary machinery-related OPMAN), M MM FM was placed in a subfunctional grouping including the FM work load for all engineering work centers (i.e., engineering space FM) and M MM rating-sensitive PM, and CM was placed in a subfunctional grouping that included B BT and A MM rating-sensitive PM and CM (i.e., main propulsion and auxiliary rating-sensitive PM and CM).

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[5] NAVPERS, Navy Enlisted Occupational Classification System (NEOCS) Study, 11 January 1974.

d. The new formal organization of the ship was then described as follows in terms associated with the hierarchial array:

1. Subfunctional groupings equated to work centers
2. Functional groupings equated to branches
3. Functional areas equated to divisions
4. Basic functional aggregations equated to departments.

3.45 The final result is summarized in Table 3.2. Three departments were constructed: Operations, responsible for all at-sea OPMAN and in-port OPMAN to the degree supportable by the petty officer manning level of the department; Maintenance, responsible for all PM, CM, and FM except for that assigned to the Support Department; and Support, responsible for PM, CM and FM work loads traditionally assigned to the Executive and Supply departments and in-port OPMAN not able to be performed by the Operations Department.

3.46 Each division, branch and (in general) work center within the Operations Department has its counterpart within the Maintenance Department. For example, Work Center OD EW (primarily responsible for EW-associated OPMAN) within the Detection Branch, Control, Detection and Delivery Division of the Operations Department has as its counterpart Work Center MC EW (primarily responsible for EW associated PM and CM) in a corresponding branch and division within the Maintenance Department.

3.47 Rating Mergers. Several ratings were notionally merged based on the functional similarities observed during the analysis of the functional hierarchy. These ratings were: PN and

TABLE 3.2
FF-1052 CLASS FUNCTIONAL ORGANIZATION

Department	Division	Branch	Work Center	Manning	Source Work Center/Work Load
Operations	Control, Detection, Delivery	Control/ Communication	OA YN	1	D1 YN; administrative support for division; OUS only
			OB CD	9	OC SM (3 billets), D1 BM (3 billets); N QM (3 billets); rating-sensitive SM, BM and QM OPMAN; prorated OUS; no PM, CM or FM
			OC RE	9	OC RM; rating-sensitive RM OPMAN; prorated OUS; no PM, CM or FM
		Detection	OD EW	6	OI EW; rating-sensitive EW OPMAN; prorated OUS; no PM, CM or FM
			OE OS	21	OI OS; rating-sensitive OS OPMAN; prorated OUS; no PM, CM or FM
			OF STG	15	F2 STG; rating-sensitive STG OPMAN; prorated OUS; no PM, CM or FM
			OG EF	6	F1 FTM; rating-sensitive FTM OPMAN; prorated OUS; no PM, CM or FM
		Delivery	OH GMT	6	F2 GMT; rating-sensitive GMT OPMAN; prorated OUS; no PM, CM or FM
	Hull, Mechanical and Electrical	Hull and Mechanical	OI MB	36	A MM (1 billet), M MM (16 billets), B BT (19 billets); rating-sensitive MM and BT OPMAN; prorated OUS; no PM, CM or FM
			OJ HT	3	R HT; rating-sensitive HT OPMAN; prorated OUS; no PM, CM or FM
		Electrical	OK EI	6	E EM (3 billets), E IC (3 billets); rating-sensitive EM and IC OPMAN; prorated OUS; no PM, CM or FM
		Support	OL SN	36	OC RM (3 billets), OC SM (3 billets), OI OS (6 billets), D1 BM (24 billets); non-rating-sensitive nonengineering OPMAN; prorated OUS; no PM, CM or FM
			OM FN	12	B BT (3 billets), M MM (6 billets), R HT (3 billets); non-rating-sensitive engineering OPMAN; prorated OUS; no PM, CM or FM
Maintenance	Control, Detection Delivery	Control/ Communications	MA CD	5	OC BM (3 billets), N QM (2 billets); rating-sensitive SM, BM and QM PM and CM; prorated OUS; no OPMAN or FM
			MB RE	2	CC RM (1 billet), OE ET (1 billet); rating-sensitive RM and ETN PM and CM; prorated OUS; no OPMAN or FM
		Detection	MC EW	1	OI EW; rating-sensitive EW PM and CM; prorated OUS; no OPMAN or FM
			MD OS	1	OI OS; rating-sensitive OS PM and CM; prorated OUS; no OPMAN or FM
			ME STG	4	F2 STG; rating-sensitive STG PM and CM; prorated OUS; no OPMAN or FM
			MF EF	3	OE ET (2 billets), F1 FTM (1 billet); rating-sensitive ETR and FTM PM and CM; prorated OUS; no OPMAN or FM
			MG FTG	3	F FTG; rating-sensitive FTG PM and CM; prorated OUS; no OPMAN or FM
		Delivery	MH GMT	1	F2 GMT; rating-sensitive GMT PM and CM; prorated OUS; no OPMAN or FM
			MI GMG	8	D2 GMG; rating-sensitive GMG PM and CM; prorated OUS; no OPMAN or FM
			MJ TM	2	F2 TM; rating-sensitive TM PM and CM; prorated OUS; no OPMAN or FM
	Hull, Mechanical and Electrical	Hull and Mechanical	MK MB	19	A MM (5 billets), M MM (5 billets) B BT (9 billets); rating-sensitive MM and BT PM and CM; prorated OUS; no OPMAN or FM
			ML EN	2	A EN; rating-sensitive EN PM and CM; prorsted OUS; no OPMAN or FM
			MM MR	1	A MR; rating-sensitive MR PM and CM; prorsted OUS; no OPMAN or FM
			MN HT	7	R HT; rating-sensitive HT PM and CM; prorsted OUS; no OPMAN or FM
		Electrical	MO EI	6	E EM (4 billets), E IC (2 billets); rating-sensitive EM and IC PM and CM; prorated OUS; no OPMAN or FM
		Support	MP SN	14	AD SN (2 billets), OI OS (1 billet), OE ET (3 billets), D1 BM (5 billets), F FTG (3 billets); non-rating-sensitive operations and weapons PM; all weapons and operations FM; prorated OUS; no CM
			MQ FN	1	R HT (1 billet), non-rating-sensitive engineering department PM; all engineering department FM; prorated OUS; no CM
			MR PO	1	X PO; 3-M coordinator, OUS only
			MS PY	1	A YN; log room yeoman, OUS only
Support	Medical	--	SA HM	2	H HM; same as original work center
	Supply	--	SB SK	5	S1 SK; rating-sensitive UT; prorated A/S; no PM; SK CM; no FM; OPMAN in port only (1 petty officer watch)
			SC DK	2	S4 DK; rating-sensitive UT; prorated A/S; no PM, CM or FM; OPMAN in port only (1 petty officer watch)
			SD MS	21	S2 MS (15 billets), S5 MS (6 billets); rating-sensitive UT; prorated A/S; no FM or PM; MS CM; OPMAN in port only (1 petty officer watch)
			SE SH	5	S3 SH; rating-sensitive UT; prorated A/S; no PM or FM; SH CM; OPMAN in port only (1 petty officer watch)
	Administration	--	SF PY	4	X PN (2 billets); X YN (2 billets); rating-sensitive UT and A/S; no PM, PM/YN CM; OPMAN in port only (1 petty officer watch)
			SG PC	1	X PC; rating-sensitive UT; prorated A/S; no PM or FM; PC CM; OPMAN in port only (1 petty officer watch)
			SH MA	1	X MA; original work load plus 1 petty officer watch in port
	Support	--	SI SN	8	S2 MS (3 billets), S5 MS (2 billets), S1 SK (2 billets); X PN (1 billet); all supply department FM; all supply PM; non-rating-sensitive UT; prorated A/S; no OPMAN or CM
Total ship	--	--	--	297	--

YN into PY; SM, BM and QM into CD; RM and ETN into RE; ETR and FTM into EF; MM and BT into MB; and EM and IC into EI.

3.48 Work Loads and Manning Levels. Table 3.2 shows the manning level assigned to each work center and briefly describes the source (baseline) work centers and work loads associated with each. The majority of the work load assigned to each work center was established during the construction of the formal organization, since subfunctions were generally described by tasks and/or type of work associated with groups of tasks. The total process used to assign the work load and manning level for each work center may be summarized as follows (note that the rate/rating sensitivity of various categories of work were determined in the same manner described under Alternative 2, discrete work-load transfers):

a. All rate/rating-sensitive at-sea OPMAN was assigned to the appropriate work center in the Operations Department. Non-rate/rating-sensitive OPMAN was assigned to Work Centers OL SN or OM FN as appropriate. Rating-sensitive in-port OPMAN was assigned to the appropriate work center in the Operations Department. Non-rate/rating-sensitive in-port OPMAN was assigned to Work Centers OL SN or OM FN as appropriate. Based on the expected petty officer strength of the Operations Department, certain rate-sensitive watches were assigned to Support Department work centers.

b. Rate/rating-sensitive PM and all CM originally assigned to the Navigation, Weapons, Operations and Engineering departments in the baseline were

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assigned to the appropriate work center in the Maintenance Department. Non-rate/rating-sensitive PM was assigned to Work Centers MP SN or MQ FN as appropriate.

c. All FM originally assigned to the Navigation, Operations, Weapons, Air and Engineering departments in the baseline was assigned to Work Centers MP SN or MQ FN as appropriate.

d. The manning level of the Operations Department's work centers was set as dictated by the watch-standing requirements. The contribution of each original (baseline) work center is shown in Table 3.2.

e. OUS was assigned to each Operations Department's work center based on the relationship of the work-center manning level to the total manning level for that rating in the baseline. For example, OJ HT manning level was set at three, based on OPMAN requirements. The baseline HT manning was 14; therefore, 3/14 of the original HT OUS was assigned to Work Center OJ HT. Similarly, 3 HT billets were assigned to Work Center OM FN (equating to 3 nonrated watchstanders), and 3/14 of the HT OUS was assigned to Work Center OM FN.

f. The remainder of the original rating manning was initially assigned to the appropriate Maintenance Department work center, along with the remainder of the associated OUS. For example: 3 HTs were assigned to OJ HT and 3 to OM FN, leaving 8 of the original 14 for initial assignment to MN HT. Of the HT's OUS, 8/14 also initially was assigned to MN HT.

g. The work load of each Maintenance Department's work center was compared to the expected capability (based on the initial manning), and, where possible without creating deferral problems, billets shifted to MP SN or MQ FN as appropriate. For example, in the case of MN HT, it was determined that a manning level of seven would allow the work load to be accomplished without creating deferral problems; hence, one HT billet was shifted to MQ FN. One-eighth of the MN HT's OUS was also shifted to MQ FN.

h. All Support Department FM (consisting of the FM originally assigned to the Executive and Supply departments) was assigned to Work Center SI SN. All of the original Executive and Supply departments' PM (totaling only about 19 hr/wk) was determined to be non-rating-sensitive and was assigned to SI SN.

i. The Support Department work-center manning was initially set at the total of the source work-center manning. An estimate of the work load/capability imbalance for each work center was made, and, where possible, manning shifted to Work Center SI SN.

j. The Supply Department work center's OUS was set at the total OUS of the source work centers minus a prorated portion (based on the work-center contribution to SI SN manning), which was shifted to Work Center SI SN.

3.49 <u>Sensitivity Parameters</u>. In addition to the work-center, work-load and manning changes discussed above, training and

leave during LVUPK were affected by the new organization. Work-center training was recomputed using the training originally assigned each source work center. The recomputation was made by prorating the training based on the new manning breakdown. Leave during LVUPK was computed for each work center in the same manner used throughout the entire study effort.

SUMMARY

3.50 The seven alternatives described in this section were applied, singly or in combination, to the FF-1052 and FFG-7 classes through a series of simulations using the SWL algorithm. The specific variations and/or forms the alternatives took for each simulation are stated, along with the descriptions of each simulation, in Sections IV and V.

IV. FF-1052 CLASS RESULTS

4.1 This section describes the simulations conducted on the FF-1052 class (except for the baseline, which is described in Section II) and presents the results of each simulation. Simulations are described in terms of the alternatives included in each. The general methods and procedures used to develop the alternatives are detailed in Section III; however, the specific data used to define the alternatives in terms of FF-1052 class parameters are listed in this section. The results are presented in a series of tables and associated narratives. The tables show both the actual simulation results as well as the differences between the simulation and reference (normally baseline) values for EOC deferral, basal slack, etc. The narratives provide a general assessment of the impact of the alternatives tested relative to the reference deferral situation.

4.2 Figure 4.1 shows the simulations conducted on the FF-1052 class. Simulation A (the baseline) was followed by seven additional simulations (B through H). Four simulations (B, D, F and G) were used to test single alternatives, FM and RCM concepts (alternatives 2 and 3) were tested together in Simulation C, and shipboard scheduling (Alternative 5) was tested in series with the notional work package (Alternative 4) in Simulation E. Simulation H incorporated six of the seven major alternatives and reflected the situation expected to be encountered under the conditions prescribed in the FF-1052 notional ship manpower document. [1/]

[1/] Presearch Incorporated, "Modified Ship Manpower Documents," Letter, Enclosure (2), 22 July 1977.

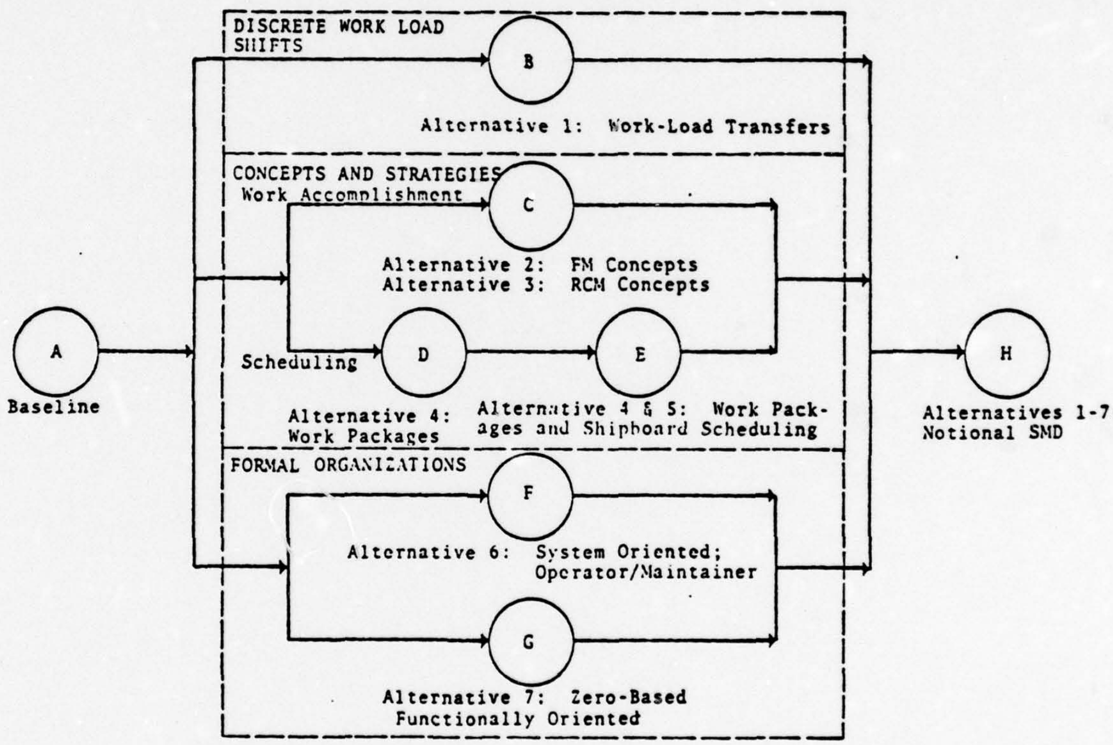

FIGURE 4.1
FF-1052 CLASS SIMULATIONS

SIMULATION B, DISCRETE WORK-LOAD SHIFTS

4.3 Simulation B was conducted by applying Alternative 1, discrete work-load transfers, to the FF-1052 class baseline data and running the SWL algorithm against the resultant data base. The processes and procedures used to identify the categories and specific amounts of work load to be transferred to and from various work centers are described in Section III. Table 4.1 shows the work centers from which work load was transferred, the work center to which the work load was transferred, and the hours per week transferred in each work category and explains the readiness conditions under which the work load was considered to be transferred and/or clarifies the specific watch and/or MIPs involved in the transfers. The bulk of the transfers consisted of FM and UT work load with only small amounts of PM/CM and OPMAN transfers required. The only A/S transfers occurred among YN work centers.

4.4 The only sensitivity parameter changed to simulate the work-load transfers was the work load itself. All other sensitivity parameters (e.g., work-center manning, OPSKED, capability detractors) used in Simulation B were the same as those used for the FF-1052 class baseline.

Simulation B Results

4.5 Table 4.2 shows the FF-1052 class status, work center by work center, as reflected in the output of the SWL algorithm for Simulation B. Tables 4.3 through 4.5 show summarized data for the simulation. In Tables 4.3 and 4.4, the percentage of work centers falling in each cell is displayed, as is the approximate change between the Simulation B value and the reference (baseline) value. For example, from Table 4.3 it can be

TABLE 4.1

WORK-LOAD TRANSFERS, SIMULATION B

From Work Center	To Work Center	Work-Load Transfers, hr/wk						Notes
		Work Category						
		OPMAN	PM	CM	FM	UT	A/S	
X YN	OC RM	18.66	--	--	--	--	--	YNC, quarterdeck watch to RMC (Cond. V)
		--	--	--	--	--	--	YN3, POOW watch to RM3 (Cond. V)
	OI EW	9.33	--	--	--	--	--	YN2, POOW watch to EW2 (Cond. V)
	OC RM	--	--	--	8.00	15.97	--	All conditions
	D1 YN	--	--	--	--	--	13.92	All conditions
	A YN	--	--	--	--	--	12.83	All conditions
OE ET	OI EW	--	--	--	13.50	--	--	All conditions
D1 BM	AD SN	--	--	--	41.67	--	--	All conditions
	F1 FTM	--	--	--	51.92	--	--	All conditions
F2 TM	F2 STG	--	--	--	8.20	2.40	--	All conditions
A EN	F1 FTM	--	--	--	--	10.00	--	All conditions
	B BT	--	--	--	11.00	--	--	All conditions
	M MM	--	0.36	0.18	--	--	--	MIP A-17-7294
	M MM	--	0.25	0.12	--	--	--	MIP A-19-24575
	M MM	--	0.41	0.21	--	--	--	MIP A-264-6083
	B BT	--	2.81	1.41	--	--	--	MIP A-133-5645
	B BT	--	2.29	1.14	--	--	--	MIP A-133-6715
A MM	F2 GMT	--	--	--	--	11.37	--	All conditions
	B BT	--	5.29	--	--	--	--	Various MIPs; FN work load
	B BT	--	--	--	39.00	--	--	All conditions
E IC	B BT	--	--	--	13.00	1.00	--	All conditions
E EM	OI OS	--	6.06	--	--	--	--	Various MIPs; nonrated work load
	OI OS	--	--	--	14.60	--	--	All conditions
	F2 GMT	--	--	--	--	11.67	--	All conditions
	B BT	--	--	--	--	1.58	--	All conditions
	R HT	--	--	--	--	7.50	--	All conditions
	E IC	--	1.16	0.58	--	--	--	MIP EL-11-12895
	E IC	--	0.36	0.18	--	--	--	MIP E-28-20555
	E IC	--	1.22	0.61	--	--	--	MIP EL-47-2XX
S2 MS	S3 SH	--	--	--	3.75	--	--	All conditions
	S1 SK	--	--	--	58.33	--	--	All conditions
	S5 MS	--	--	--	11.42	--	--	All conditions
S3 SH	F1 FTM	--	--	--	--	36.75	--	All conditions
S4 DK	R HT	--	--	--	--	1.08	--	All conditions

TABLE 4.2
FF-1052 CLASS STATUS WITH DISCRETE WORK-LOAD SHIFTS--SIMULATION B

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
X	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	PC	0.0	1.3	0.1	0.60	8.2	0.4	0.1
X	PN	0.0	1.9	0.0	1.36	3.4	1.2	0.0
X	YN	2.0	15.3	4.4	4.72	0.2	0.8	6.7
M	QM	0.0	1.6	0.3	3.71	3.5	1.9	1.4
H	HM	0.0	1.2	0.0	1.06	6.2	0.7	0.0
OC	RM	0.0	0.5	0.0	2.25	7.2	4.9	0.0
OC	SM	0.0	0.3	0.0	0.41	13.5	2.2	0.0
OE	ET	0.0	8.4	2.1	9.94	6.6	1.9	7.9
OI	EW	0.0	1.6	0.0	2.53	15.5	1.2	0.0
OI	OS	0.0	0.0	0.0	-6.96	4.0	4.3	0.0
AD	SN	0.4	2.3	0.6	1.26	0.9	0.8	0.9
D1	BM	0.0	1.9	0.6	32.97	0.5	14.0	17.0
D1	YN	0.8	4.8	1.7	0.25	1.9	0.4	1.3
D2	GMG	0.0	1.7	0.4	6.75	0.9	3.0	2.8
F	FTG	0.0	1.8	0.3	4.44	16.7	1.9	1.4
F1	FTM	0.0	2.1	0.4	5.01	15.4	1.8	1.6
F2	GMT	0.0	0.6	0.0	1.15	16.0	1.5	0.0
F2	STG	0.0	0.4	0.0	2.45	5.5	5.5	0.0
F2	TM	0.0	3.9	1.1	2.59	1.0	0.7	1.6
A	EN	4.5	10.8	6.0	2.35	0.0	0.6	7.6
A	MM	0.0	3.3	0.9	6.09	0.8	2.1	3.9
A	MR	0.0	1.9	0.4	0.71	8.2	0.3	0.3
A	YN	0.6	4.5	1.4	0.23	2.0	00.4	1.0
B	BT	0.0	2.1	0.1	17.12	1.0	12.8	4.6
E	EM	0.0	3.4	0.0	2.88	1.8	2.6	0.0
E	IC	0.0	2.2	0.6	4.30	0.5	1.8	2.4
M	MM	0.0	3.6	0.6	20.51	0.3	9.9	12.8
R	HT	0.0	1.5	0.3	10.42	3.4	4.7	3.2
S1	SK	0.4	2.2	1.0	4.65	0.6	2.8	5.8
S2	MS	0.0	2.0	0.6	15.70	0.5	6.7	8.2
S3	SH	0.0	2.0	0.6	4.46	1.9	1.8	2.3
S4	DK	0.0	2.0	0.6	2.00	0.6	0.8	1.0
S5	MS	0.3	2.0	0.6	5.64	0.7	3.0	4.1
Total ship		0.1 1/	2.0 1/	0.5 1/	183.01 2/	8.3 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.3

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH DISCRETE WORK-LOAD SHIFTS, SIMULATION B

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	57.1 (+34)	22.9 (0)**	14.3 (-11)	94.3 (+23)
3-10	5.7 (0)	--	--	5.7 (0)
>10	0 (-23)	--	--	0 (-23)
Total	62.8 (+11)	22.9 (0)	0 (-11)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 0.5% EOC deferral, 8.3% basal slack.

TABLE 4.4

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH DISCRETE WORK-LOAD SHIFTS, SIMULATION B

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	20.0 (-20)	--	--	20.0 (-20)
1-5	71.4 (+40)**	0 (-6)	0 (-14)	71.4 (+20)
>5	2.9 (+3)	5.7 (+6)	0 (-9)	8.6 (0)
Total	94.3 (+23)	5.7 (0)	0 (-23)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 0.5% EOC deferral, 1.9% maximum minus minimum deferral.

TABLE 4.5

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH DISCRETE WORK-LOAD SHIFTS, SIMULATION B*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Executive	3 (0)	7 (-7)	1:2.3
Navigation/ Operations	16 (0)	9 (+4)	1:0.6
Weapons/Air	30 (+1)	27 (+4)	1:0.9
Engineering	35 (-1)	36 (+1)	1:1.0
Supply/Medical	26 (0)	21 (-2)	1:1.3
Total ship, thou man-hours	2,461 (0)	12.7 (-116.3)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

seen that 57.1% of the work centers have less than 3% EOC deferral and less than 5% basal slack. This is an increase of approximately 34% (+34) over the baseline number of 22.9%. Similarly in Table 4.5, the number in parentheses indicates the change observed between Simulation B and the baseline.

4.6 Analysis of Results. The following are the major results of Simulation B (and, hence, Alternative 1, discrete work-load shifts):

a. The total EOC deferral for the ship has been reduced from 129,000 man-hours (5.3% of the total work load for the cycle) to 12,700 man-hours (0.5% of the total work load)

b. The EOC basal slack for the ship has been reduced from 12.3% of the total capability in the baseline condition to 8.3% with work-load transfers applied.

c. Referring to Table 4.3, only 5.7% (two work centers) exhibit 3% or more EOC deferral, and these work centers (X YN and A EN) have less than 10% EOC deferral. Of the work centers, 94.3% (33 of 35) have less than 3% EOC deferral. This improvement in EOC deferral has been made simultaneously with an improvement in manpower utilization efficiency as reflected by the increase in the percentage of work centers with less than 5% basal slack and a corresponding decrease in percentage of work centers with a basal slack greater than 15%.

d. Referring to Table 4.4, a certain negative impact on deferral may be observed. Although the EOC

deferral has been reduced significantly, the range of deferral, encountered at all observation points, has increased slightly from the ship's total maximum minus minimum deferral range of 1.3% existing in the baseline condition to 1.9% for this simulation. A concentration (71.4%) exists in work centers that exhibit a 1% to 5% range in deferral over the cycle. This fact is further reflected by the observation that the maximum number of billets needed to eliminate deferral was 193.53 for the baseline and remains at 183.01 for this simulation, despite the large reduction in deferral that occurred. The need to examine the status of work centers at more than a single point (for example EOC) is reemphasized by these results. The work-load transfers have significantly reduced both the EOC and internal cycle deferrals; however, the reduction has not been distributed uniformly. For example, for Work Center X YN, the EOC deferral was reduced from 47.6% to 4.4%, a relative decrease of over 90%, yet the maximum deferral for the work center was reduced from 52.2% to 15.3%, a relative decrease of about 70%. In practice, this fact may be quite significant. In viewing just the EOC deferral, one might decide that the 4.4% exhibited by X YN was "satisfactory" since the overall operation of the ship would not be affected significantly. At certain points within the operational schedule, however, the X YN work-center deferral may reach over 15% and may result in an adverse effect on the ship.

e. The distribution of the relative burden of the remaining deferral is exhibited in Table 4.5. A small shift in work load from the Engineering Department to the Weapons/Air departments is shown. The EOC deferral is not only significantly lower than the baseline value, but it is generally spread in a more even pattern (relative to associated work loads) throughout the departments.

Simulation B Summary

4.7 The following statements summarize the effects of the discrete work-load shifts:

a. The work-load shifts simulated represent roughly 5% of the total work load for the ship. The shifting of this amount of work load results in a significant decrease in expected deferral throughout the operating cycle.

b. The inference of the decrease is that the organic maintenance capability of the ship will be significantly improved as well. This inference is drawn from the data in Table 4.6, which shows that the expected deferral for the Engineering and Weapons/Air departments will be reduced by a total of over 46,000 man-hours at the end of the cycle (EOC). Since the vast majority of the maintenance work load on the ship resides in these two departments, a decrease in their expected overall deferral probably will translate into a decrease in deferred maintenance.

TABLE 4.6

APPROXIMATE EOC DEFERRAL--FF-1052 CLASS, SIMULATION B

Department	EOC Deferral, thou man-hours		
	Baseline	Simulation B	Change
Executive	18.1	0.9	-17.2
Navigation/ Operations	6.4	1.1	-5.3
Weapons/Air	29.7	3.4	-26.3
Engineering	45.1	4.6	-40.5
Supply/Medical	29.7	2.7	-27.0
Total ship	129.0	12.7	-116.3

c. Although the EOC deferral will be much lower, certain work centers are still expected to exhibit significant deferral at one or more points during the operating schedule. Additional alternatives (beyond work-load tranfers as simulated in this portion of the study) will be required to reduce EOC deferral or intercycle deferral below the levels attained in Simulation B.

SIMULATION C, FM AND RCM CONCEPTS

4.8 Simulation C was conducted by applying Alternative 2, new FM concepts, and Alternative 3, reliability-centered maintenance (RCM) concepts, to the FF-1052 class baseline data and running the SWL algorithm against the resultant data base.

Sensitivity Parameters

4.9 The changes in sensitivity parameters required to describe each alternative are discussed in Section III. Table 4.7 summarizes the actual sensitivity parameters used in Simulation C. Four FM teams were used, one for each department except for the Executive and Air departments. The Executive Department FM was assigned to the Supply Department FM team, and the Air Department FM was assigned to the Weapons Department FM team.

4.10 Table 4.8 shows the work-center manning used for the simulation and, for reference purposes, the original (baseline) manning. The decrements in original work-center manning (necessary to construct the FM teams) were calculated based on the third manning option described for Alternative 2 in Section III. Simply stated, decrements were selected based on the ability of the work center to sustain a manning reduction without

TABLE 4.7

SENSITIVITY PARAMETERS--FF-1052 CLASS, SIMULATION C

Parameter	Value/Comment
Work centers	Baseline plus four FM teams: FM1 SN--Operations Department FM2 SN--Weapons Department FM3 FN--Engineering Department FM4 SN--Supply Department
OPSKED	Same as baseline
Manning	Total same as baseline, work center as shown in Table 4.9
Formal organization	Baseline plus four FM teams, one for each major department
Work loads	Baseline modified as follows: PM work loads = 0.621 x original PM work loads (reflects RCM concept) FM = 0 (all work centers except FM teams and H HM) FM = baseline (H HM) FM = 0.70 x sum of source work-center FM work loads (FM teams, see Table 4.9) All other work loads: same as baseline
Work-load variances	Not used
Work and productive allowances	Same as baseline
Workweek	Same as baseline

TABLE 4.7 (Cont)

Parameter	Value/Comment
Detractors:	
Service diversions	Same as baseline
Training	Non-FM team work centers: same as baseline
	FM teams: 0.125 hr/billet/wk
UA/TAD	Same as baseline
Leave	Non-FM team work centers: same as baseline
	FM teams: at sea; same as baseline (1.45 hr/billet/wk)
	in port (non-LVUPK); same as baseline (1.52 hr/billet/wk)
	in port (LVUPK) calculated as shown in Appendix A (18.15 hr/billet/wk)

TABLE 4.8

MANNING COMPARISON--FF-1052 CLASS, BASELINE TO SIMULATION C

Department	Work Center		Manning		
	Division	Rating	Baseline	Simulation C	Change
Executive	X	PO	1	1	0
	X	MA	1	1	0
	X	PC	1	1	0
	X	PN	3	3	0
	X	YN	2	2	0
Navigation	N	QM	5	5	0
Medical	H	HM	2	2	0
Operations	OC	RM	13	13	0
	OC	SM	6	6	0
	OE	ET	6	6	0
	OI	EW	7	7	0
	OI	OS	29	26	-3
Air	AO	SN	2	2	0
Weapons	D1	BM	35	31	-4
	D1	YN	1	1	0
	D2	GMG	8	8	0
	F	FTG	6	6	0
	F1	FTM	7	7	0
	F2	GMT	7	7	0
	F2	STG	19	15	-4
	F2	TM	2	2	0
Engineering	A	EN	2	2	0
	A	MM	6	6	0
	A	MR	1	1	0
	A	YN	1	1	0
	B	BT	31	29	-2
	E	EM	7	7	0
	E	IC	5	5	0
	M	MM	27	23	-4
	R	HT	14	13	-1
Supply	S1	SK	7	5	-2
	S2	MS	18	16	-2
	S3	SH	5	5	0
	S4	DK	2	2	0
	S5	MS	8	7	-1
FM teams	FM1	SN(OPS)	--	3	+3
	FM2	SN(WEPS)	--	8	+8
	FM3	FN(ENG)	--	7	+7
	FM4	SN(SUP)	--	5	+5

aggravating (or causing) deferral problems. Such ability was determined in light of the baseline deferral patterns and the deferral patterns anticipated to exist once the original work centers' baseline work loads are modified to reflect the new FM and RCM concepts.

4.11 Table 4.9 displays the specific sources from which FM team work load was constructed. Note that in this simulation, only FM work load was assigned to the FM teams. In view of this, the training associated with the FM teams was set at 0.125 hr/billet/wk, based on the amount of training directly associated with the new FM concepts as described in Section III. Use of this training value resulted in the 18.15 hr/billet/wk leave factor (during LVUPK) calculated for the FM teams.

Simulation C Results

4.12 Table 4.10 displays the FF-1052 class status, work center by work center, with the new FM and RCM concepts applied to the class. To facilitate the following discussions, the four FM teams appear together at the bottom of the table. The department to which each team is assigned is shown in parentheses. Tables 4.11 through 4.14 provide summaries of the results in the same format as previously described for Simulation B. The changes between Simulation C and the reference (baseline) status are again shown in parentheses in the tables.

4.13 Analysis of Results. A significant reduction in deferral is depicted by the results. Shipwide, the EOC deferral dropped from 5.3% in the baseline condition to 1.5% with the new FM and RCM concepts applied. A corresponding improvement relative to the percentage of work centers with less than 3% EOC deferral is apparent, as is the fact that this improvement is accompanied by

TABLE 4.9

FM TEAM WORK LOAD--FF-1052 CLASS, SIMULATION C*

Source Work Center/ FM Team		FM, hr/wk	
Division	Rating	Condition IV	Condition V
N	QM	24.00	36.30
OC	RM	32.40	29.10
OC	SM	19.40	20.50
OE	ET	15.00	35.50
OI	EW	15.00	18.20
OI	OS	54.00	35.20
Total		159.80	174.80
FM1	SN	111.86	122.36
AD	SN	24.00	0.00
D1	BM	244.07	346.60
D1	YN	4.00	0.00
D2	GMG	11.00	22.50
F	FTG	63.00	23.50
F1	FTM	10.00	4.30
F2	GMT	20.00	3.60
F2	STG	52.98	33.80
F2	TM	12.00	8.20
Total		441.05	442.50
FM2	SN	308.74	309.75
A	EN	22.00	11.00
A	MM	39.00	42.40
A	MR	6.00	9.50
A	YN	4.00	0.00
B	BT	125.01	109.50
E	EM	39.04	14.60
E	IC	17.00	12.90
M	MM	92.28	182.20
R	HT	44.60	15.60
Total		388.93	397.70
FM3	FN	272.25	278.39
X	PO	0.00	0.00
X	MA	0.00	0.00
X	PC	4.00	4.10
X	PN	11.00	1.00
X	YN	8.00	27.50
S1	SK	40.00	3.80
S2	MS	161.00	155.00
S3	SH	22.00	22.50
S4	DK	1.00	6.40
S5	MS	89.03	14.60
Total		336.03	234.90
FM4	SN	235.22	164.43

* Baseline values for source work centers, Simulation C values for FM team (FM team FM = 0.7 x total of source work-center FM).

TABLE 4.10

FF-1052 CLASS STATUS WITH FM AND RCM CONCEPTS--SIMULATION C

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
X	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	PC	0.0	0.5	0.0	0.21	21.3	0.3	0.0
X	PN	0.0	1.0	0.0	1.28	8.6	1.2	0.0
X	YN	37.1	43.2	38.4	7.93	0.0	1.4	37.0
N	QM	0.0	0.4	0.0	0.81	20.7	1.7	0.0
H	HM	0.0	1.1	0.0	0.90	10.9	0.7	0.0
OC	RM	0.0	0.0	0.0	-1.19	7.1	4.5	0.0
OC	SM	0.0	0.0	0.0	-0.25	15.7	2.2	0.0
OE	ET	0.0	3.8	1.8	8.49	17.1	1.9	2.3
OI	EW	0.0	0.0	0.0	-0.68	15.6	0.8	0.0
OI	OS	0.0	0.0	0.0	-9.27	4.5	3.8	0.0
AD	SN	0.0	0.0	0.0	-1.25	52.4	0.2	0.0
D1	BM	0.0	1.9	0.0	15.19	3.0	12.4	0.6
D1	YN	0.0	0.0	0.0	-0.13	46.8	0.2	0.0
D2	GMG	0.0	1.2	0.0	3.74	13.3	2.6	0.0
F	FTG	0.0	1.0	0.0	1.70	17.9	1.4	0.0
F1	FTM	0.0	0.0	0.0	-3.65	15.4	0.6	0.0
F2	GMT	0.0	0.0	0.0	-1.33	15.9	1.0	0.0
F2	STG	0.0	0.2	0.0	-1.13	6.9	5.0	0.0
F2	TM	0.0	3.7	1.1	2.37	15.3	0.7	0.5
A	EN	16.6	26.2	18.5	3.57	0.0	0.8	10.4
A	MM	0.0	3.9	1.0	6.40	6.7	2.2	1.6
A	MR	0.0	0.0	0.0	-0.10	37.9	0.2	0.0
A	YN	0.0	0.0	0.0	-0.12	45.2	0.2	0.0
B	BT	.0	0.4	0.0	5.53	3.3	10.9	0.0
E	EM	0.0	2.7	0.3	0.50	0.9	2.8	0.6
E	IC	0.0	1.7	0.3	3.29	10.1	1.8	0.5
M	MM	0.0	1.2	0.0	9.08	4.8	8.4	0.0
R	HT	0.0	1.5	0.2	8.53	8.9	4.4	0.7
S1	SK	0.0	1.4	0.0	1.86	5.9	2.0	0.0
S2	MS	0.0	1.7	0.3	11.48	3.8	6.3	1.7
S3	SH	4.1	5.7	5.0	5.31	0.0	2.2	7.4
S4	DK	0.0	1.6	0.3	1.58	4.9	0.8	0.2
S5	MS	0.0	1.7	0.3	4.68	11.3	2.6	0.5
FM1	SN(OPS)	3.5	10.3	5.1	5.18	0.0	1.5	5.2
FM2	SN(WEPS)	2.2	8.3	3.7	12.70	0.0	3.9	10.0
FM3	FN(ENG)	3.9	9.7	5.4	11.61	0.0	3.5	12.9
FM4	SN(SUP)	3.6	5.9	4.6	5.99	0.0	2.5	7.8
Total ship		1.2 1/	2.6 2/	1.5 1/	139.91 2/	17.4 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.11

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH FM AND RCM CONCEPTS, SIMULATION C

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	17.9 (-5)	25.6 (+3)	38.6 (+13)**	82.1 (+11)
3-10	12.8 (+7)	--	--	12.8 (+7)
>10	5.1 (-18)	--	--	5.1 (-18)
Total	35.8 (-16)	25.6 (+3)	38.6 (+13)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 1.5% EOC deferral, 17.4% basal slack.

TABLE 4.12

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH FM AND RCM CONCEPTS, SIMULATION C

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	< 3	3-10	>10	Total
<1	41.0 (+1)	--	--	41.0 (+1)
1-5	41.1 (+10)**	5.1 (-1)	0 (-14)	46.2 (-5)
>5	--	7.7 (+8)	5.1 (-4)	12.8 (+4)
Total	82.1 (+11)	12.8 (+7)	5.1 (-18)	100.0 (0)

* Number in parentheses indicate the change from the baseline.

** Ship: 1.5% EOC deferral, 1.4% maximum minus minimum deferral.

TABLE 4.13

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH FM AND RCM CONCEPTS, SIMULATION C*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Executive	3 (0)	37 (+23)	1:12.3
Navigation/ Operations	16 (0)	7 (+2)	1:0.4
Weapons/Air	28 (-1)	11 (-12)	1:0.4
Engineering	35 (-1)	27 (-8)	1:0.8
Supply/Medical	17 (+1)	18 (-5)	1:1.1
Total ship, thou man-hours	2,229 (-232)	32.7 (-96.3)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

TABLE 4.14

APPROXIMATE EOC DEFERRAL-- FF-1052 CLASS, SIMULATION C

Department	EOC Deferral, thou man-hours		
	Baseline	Simulation C	Change
Executive	18.1	12.1	-6.0
Navigation/ Operations	6.4	2.3	-4.1
Weapons/Air	29.7	3.6	-26.1
Engineering	45.1	8.8	-36.3
Supply/Medical	29.7	5.9	-23.8
Total ship	129.0	32.7	-96.3

a certain loss in efficiency as demonstrated by the increase in shipwide basal slack and rise in the percentage of work centers with greater than 15% basal slack.

4.14 Since the fundamental principal of both concepts tested by this simulation is the reduction of ship work load, it is necessary to determine whether or not the change in deferral is commensurate with the work-load change. The total work load has been reduced by 232,000 man-hours by the incorporation of the new concepts. The reduction in FM work load is approximately 400 hr/wk, or, applying the appropriate productive allowance and expressing the result as a total for the operating cycle, about 112,000 man-hours. Similarly, the reduction in PM work load is roughly 330 hr/wk, or, applying the appropriate make-ready/put-away and productive allowances and expressing the result as a total for the operating cycle, approximately 120,000 man-hours. Had these reductions been perfectly aligned, work center by work center, with the deferral exhibited in the baseline, the EOC deferral for the simulation would have been zero. In fact, however, the 232,000-man-hour work-load reduction resulted in only a 96,300-man-hour change in EOC deferral. The impact of the remaining work-load reduction may be considered to show up in the form of the increase in basal slack observed.

4.15 The results indicate that the EOC deferral apparently will be concentrated in Work Center X YN (37.0%) and the FM teams (35.9%), with the remainder of the work centers collectively exhibiting only 27.1% of the total deferral. This situation, however, results from the manner in which the FM team manning was constructed. If, for example, the decision is made to set the FM team manning at the value required to accomplish all the FM, then the FM team deferrals will be zero and the deferrals for the work centers from which the additional FM team manning was obtained will rise accordingly.

Simulation C Summary

4.16 Both the new FM and RCM concepts will improve the organic maintenance capability of ships. The improvement, however, will not occur totally efficiently. Without simultaneous application of other alternatives, portions of the work-load decrements associated with the concepts will result in an increase in basal slack rather than elimination of deferral.

4.17 Assuming that FM teams will be constructed without increasing total ship manning, the manner in which work centers are identified and called on to provide personnel to man the teams will determine not only the net shipwide decrease in expected deferral due to the implementation of the new concept but also the benefits accruing to individual work centers relative to their capability to accomplish other work.

SIMULATION D, IN-PORT MAINTENANCE PACKAGES

4.18 Simulation D was conducted by applying Alternative 4, work packages, to the FF-1052 class baseline data and running the SWL algorithm against the resultant data base. For this simulation, the notional work package for the FF-1052 depicted in Table E.1 was used without modification.

Sensitivity Parameters

4.19 As discussed in Section III, changes in two sensitivity parameters were required to simulate the notional work packages. First, the baseline average weekly PM and CM work loads were modified to reflect that some PMS-associated work would be performed only during specified TAV/SRA phases, and, hence,

the average weekly PM and CM would be reduced in other phases. Second, work-load variances were constructed to simulate the presence of the notional work-package work loads in the TAV/SRA phases. All other sensitivity parameters used for this simulation were the same as those used for the FF-1052 class baseline.

Simulation D Results

4.20 Table 4.15 displays the results of applying the notional work package to the FF-1052 class. Tables 4.16 through 4.19 summarize the results in the format used for previous simulations.

4.21 Analysis of Results. The overall effect of the notional work package was to raise the expected EOC deferral slightly (from 5.3% for the baseline to 5.8% for Simulation D). At the same time, the basal slack dropped to 11.4% from the baseline level of 12.3%. These changes were caused primarily by the increase in work load (roughly 42,000 man-hours shipwide) arising from the non-PMS-associated work found in the notional work packages. Note, however, that only 17,000 man-hours of deferral were created by this work-load increase, primarily since a significant portion of the work centers had excess capability during the TAV/SRA phases in the baseline condition (even though they may have exhibited net deferral over the entire cycle) and, hence, were able to absorb all or part of the additional work load without additional deferral being created.

4.22 As might be expected, the Engineering Department experienced the largest increase in deferral due to the notional work package. The increase in deferral experienced by the Supply Department was caused by the manner in which the notional work package vent-cleaning requirements were prorated among work centers.

TABLE 4.15
FF-1052 CLASS STATUS WITH NOTIONAL WORK PACKAGE--SIMULATION D

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
X	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	PC	0.0	1.4	0.1	0.65	6.4	0.4	0.0
X	PN	0.0	1.9	0.0	1.36	3.4	1.1	0.0
X	YN	46.4	52.2	47.6	10.18	0.0	1.5	12.1
N	QM	0.0	1.6	0.3	3.76	2.9	1.9	0.1
H	HM	0.0	1.4	0.1	1.11	5.3	0.7	0.0
OC	RM	0.0	0.0	0.0	-0.17	7.1	4.6	0.0
OC	SN	0.0	0.3	0.0	0.41	12.6	2.2	0.0
OE	ET	10.0	20.0	12.6	13.13	0.0	2.3	4.9
OI	EW	0.0	0.8	0.0	1.05	15.7	1.0	0.0
OI	OS	0.0	0.0	0.0	-7.49	3.9	4.1	0.0
AD	SN	0.0	0.0	0.0	-0.74	52.5	0.3	0.0
D1	BM	6.8	7.8	7.7	40.54	0.0	14.9	19.8
D1	YN	0.0	0.0	0.0	-0.04	41.6	0.2	0.0
D2	GMG	0.0	1.9	1.5	7.12	0.2	3.0	0.8
F	FTG	0.0	2.7	0.4	4.67	14.0	1.9	0.1
F1	FTM	0.0	0.0	0.0	-1.83	15.4	0.8	0.0
F2	GMT	0.0	0.0	0.0	-0.51	16.0	1.3	0.0
F2	STG	0.0	0.3	0.0	2.14	5.4	5.3	0.0
F2	TM	15.4	18.9	16.5	3.62	0.0	0.9	2.4
A	EN	40.6	46.0	41.8	4.66	0.0	1.0	7.4
A	MM	24.1	26.5	25.6	10.38	0.0	2.7	12.1
A	MR	0.0	1.9	0.4	0.71	8.2	0.3	0.0
A	YN	0.0	0.0	0.0	-0.04	39.9	0.2	0.0
B	BT	0.0	0.8	0.4	13.30	3.1	11.9	1.0
E	EM	20.0	21.5	20.1	6.05	0.0	3.1	10.9
E	IC	3.7	6.3	5.4	4.78	0.0	1.9	1.8
M	MM	0.5	3.3	1.5	20.29	0.0	9.8	2.7
R	HT	0.0	1.5	0.3	9.93	4.1	4.6	0.2
S1	SK	0.0	0.1	0.0	0.48	14.7	2.1	0.0
S2	MS	11.1	12.6	11.8	21.48	0.0	7.5	15.1
S3	SH	17.7	19.7	18.6	7.51	0.0	2.2	7.2
S4	DK	6.8	8.3	7.6	2.45	0.0	0.8	1.1
S5	MS	0.0	1.6	0.2	9.14	2.8	2.9	0.1
Total ship		5.3 1/	6.8 2/	5.8 1/	196.90 2/	11.4 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.16

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL WORK PACKAGES, SIMULATION D

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	20.0 (-3)	22.9 (0)	25.6 (0)	68.5 (-3)
3-10	8.6 (+3)	**	--	8.6 (+3)
>10	22.9 (0)	--	--	22.9 (0)
Total	51.5 (0)	22.9 (0)	25.6 (0)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 5.8% EOC deferral, 11.4% basal slack.

TABLE 4.17

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL WORK PACKAGES, SIMULATION D

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	<10	Total
<1	42.9 (+3)	--	--	42.9 (-3)
1-5	25.6 (-6)	8.6 (+3)**	14.3 (0)	48.5 (+3)
>5	--	--	8.6 (0)	8.6 (0)
Total	68.5 (-3)	8.6 (+3)	22.9 (0)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 5.8% EOC deferral, 1.5% maximum minus minimum deferral.

TABLE 4.18

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH NOTIONAL WORK PACKAGES, SIMULATION D*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Executive	3 (0)	12 (-2)	1:4.0
Navigation/ Operations	16 (0)	5 (0)	1:0.3
Weapons/Air	29 (0)	23 (0)	1:0.8
Engineering	36 (0)	36 (+1)	1:1.0
Supply/Medical	16 (0)	24 (+1)	1:1.5
Total ship, thou man-hours	2,503 (+42)	146 (+17)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

TABLE 4.19

APPROXIMATE EOC DEFERRAL--FF-1052 CLASS, SIMULATION D

Department	EOC Deferral, thou man-hours		
	Baseline	Simulation B	Change
Executive	18.0	17.5	-0.5
Navigation/ Operations	6.4	7.3	+0.9
Weapons/Air	29.7	33.6	+3.9
Engineering	45.2	52.6	+7.4
Supply/Medical	29.7	35.0	+5.3
Total ship	129.0	146.0	+17.0

Simulation D Summary

4.23 The inclusion of non-PMS work in the FF-1052 notional work package led to a slight increase in EOC deferral. The impact of the notional work package on the organic maintenance capability of the ship, however, is ambiguous. On one hand, the increase in deferral is directly associated with the work package and, hence, would appear to be maintenance related. On the other hand, the increased management control of and attention to maintenance that could result from the use of a work package might indicate that less maintenance deferral would occur, with a corresponding increase in deferral of nonmaintenance work taking place.

4.24 Additional ambiguity concerning the impact of the notional work package arises from the necessity to make certain assumptions regarding the assignments of work loads, such as fire watches to work centers. For Simulation D, this type of work load was prorated among work centers. The total amount of work load of this nature is significant, and the rationale used to assign it to various work centers will affect the deferral patterns exhibited by the ship.

SIMULATION E, SHIPBOARD SCHEDULING

4.25 FF-1052 class Simulation E was conducted by applying Alternative 5, shipboard scheduling, to the data established for the FF-1052 with a notional work package included and running the SWL algorithm against the resultant data base. The rationale for basing Simulation E on data that included the notional work package was the following: the notional work package itself reflects a form of scheduling in that certain tasks must be accomplished during specified maintenance periods; therefore,

consideration of shipboard scheduling is a logical extension/broadening of the general scheduling principle. In addition, the concentration of significant maintenance efforts into certain phases as specified by the notional work package would appear to mandate that work centers review their work schedules to ensure that other (i.e., non-work-package) work would not interfere with the accomplishment of the work-package work load during the TAVs and SRAs.

Sensitivity Parameters

4.26 Work-load variances were used to describe the shipboard scheduling. Variances were computed using the procedure outlined in Section III. Since the variances displayed alone would be of little value to those not intimately familiar with SWL algorithm input formats and logic, the effect of the variances relative to the type of scheduling they were used to simulate will be stated narratively in lieu of the tabular format used elsewhere in this report to describe sensitivity parameters.

4.27 The deferral/slack patterns resulting from Simulation D reflected the notional work package and were reviewed to determine the scheduling to be applied to each work center for Simulation E. Work centers fell into four general categories:

a. Work centers with slack in each phase, indicating that no shipboard scheduling needs to be simulated to eliminate deferral. Nine such work centers existed: X PO, X MA, OC RM, OI OS, AD SN, D1 YN, F1 FTM, F2 GMT and A YN.

b. Work centers with deferral existing for one phase type, leave and upkeep (LVUPK), only. Eight

such work centers existed: X PC, N QM, OI EW, F FTG, F2 STG, A MR, R HT, and S1 SK. For these work centers, work load was scheduled out of the LVUPK phase and into other in-port or at-sea phases. The scheduling associated with Work Center N QM was typical of that used for work centers in this category. For N QM, 6.83 hr/wk FM and 41.67 hr/wk OUS were scheduled out of each LVUPK phase. The work load was scheduled evenly into all at-sea phases, resulting in an increase of 0.80 hr/wk FM and 4.90 hr/wk OUS in the work center's average at-sea work load.

c. Work centers for which work load was scheduled out of in-port periods and into at-sea periods. Eleven work centers--X YN, OE ET, D1 BM, F2 TM, A EN, A MM, E IC, M MM, S2 MS, S3 SH, and S4 DK--fell into this category. Work Center A EN was typical of this category of work centers. Table 4.20 shows the scheduling applied to Work Center A EN. Work load was scheduled out of LVUPK, out of the remainder of the in-port phases, and into at-sea phases.

d. Work centers for which work load was scheduled out of LVUPK phases, out of at-sea phases and into non-LVUPK in-port phases. Seven work centers--X PN, H HM, OC SM, D2 GMG, B BT, E EM and S5 MS--fell into this category. The scheduling applied to Work Center B BT, shown in Table 4.21, was typical of that used for work centers in this category. Note that for this work center, work load was scheduled into only the in-port cold-iron upkeep (UPK CI) phases.

TABLE 4.20

WORK CENTER A EN SHIPBOARD SCHEDULING--
SIMULATION E

Phase/Direction	Work Load Scheduled, hr/wk		
	PM	FM	OUS
Out of LVUPK	3.21	3.33	25.17
Out of non-LVUPK in-port phases	--	--	13.71
Into at-sea phases	0.38	0.39	13.04

TABLE 4.21

WORK CENTER B BT SHIPBOARD SCHEDULING--
SIMULATION E

Phase/Direction	Work Load Scheduled, hr/wk		
	PM	FM	OUS
Out of LVUPK	13.17	62.50	83.33
Out of at-sea phases	--	--	0.83
Into UPKCI	4.39	20.83	30.14

Simulation E Results

4.28 Table 4.22 displays the results of Simulation E, work center by work center. Tables 4.23 through 4.25 show summary information for the simulation. Note that the numbers in parentheses in these tables reflect the changes between Simulation E (i.e., including both the notional work package and shipboard scheduling) and Simulation D (in which only the notional work package was reflected).

4.29 Analysis of Results. The total ship EOC deferral for Simulation E is 5.6%, down slightly from the 5.8% present in Simulation D. Basal slack is also lower (11.4% in Simulation E versus 11.5% in Simulation D). These changes result primarily from the scheduling associated with work centers that had only small amounts (less than 1%) EOC deferral in the reference (Simulation D) condition. For such work centers, scheduling successfully eliminated all EOC deferral. For work centers with larger amounts of deferral, scheduling had less effect on EOC deferral. These work centers typically had deferral in all or most phases in the reference condition and were characterized by exhibiting little or no basal slack. Scheduling alone could not be expected to significantly reduce the EOC deferral for such work centers, since the periods of excess capability into which work load could be scheduled to reduce deferral were limited or nonexistent.

4.30 Although the shipwide reduction in EOC deferral caused by scheduling was small, the maximum deferral encountered during any of the observation points throughout the OPSKED was reduced for all work centers, and, for the ship as a whole, the maximum deferral dropped to 6.0% from the 6.8% experienced in Simulation

TABLE 4.22

FF-1052 CLASS STATUS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING--SIMULATION E

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % Total Ship
Division	Rating	Min.	Max.	EOC				
X	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
X	PC	0.0	0.0	0.0	0.00	7.4	0.4	0.0
X	PN	0.0	0.0	0.0	0.00	0.0	1.1	0.0
X	YN	46.8	50.2	47.8	8.15	0.0	1.5	12.6
N	QM	0.0	0.0	0.0	-0.01	2.6	1.9	0.0
H	HM	0.0	0.0	0.0	0.01	5.0	0.7	0.0
OC	RM	0.0	0.0	0.0	-0.17	7.1	4.6	0.0
OC	SM	0.0	0.0	0.0	0.01	12.6	2.2	0.0
OE	ET	6.0	13.9	12.6	9.59	0.1	2.3	5.1
OI	EW	0.0	0.0	0.0	0.00	15.6	1.0	0.0
OI	OS	0.0	0.0	0.0	-7.49	3.9	4.1	0.0
AD	SN	0.0	0.0	0.0	-0.74	52.5	0.3	0.0
D1	BM	7.5	8.2	7.7	7.68	0.0	14.9	20.5
D1	YN	0.0	0.0	0.0	-0.04	41.6	0.2	0.0
D2	GMG	1.3	1.7	1.3	0.45	0.0	3.0	0.7
F	FTG	0.0	1.2	0.0	2.16	14.8	1.9	0.0
F1	FTM	0.0	0.0	0.0	-1.83	15.4	0.8	0.0
F2	GMT	0.0	0.0	0.0	-0.51	16.0	1.3	0.0
F2	STG	0.0	0.0	0.0	-0.03	5.4	5.3	0.0
F2	TM	15.4	17.1	16.4	1.21	0.0	0.9	2.5
A	EN	41.0	43.8	41.7	2.44	0.0	1.0	7.6
A	MM	23.8	27.0	25.6	6.96	0.0	2.7	12.5
A	MR	0.0	0.0	0.0	0.00	7.8	0.3	0.0
A	YN	0.0	0.0	0.0	-0.04	39.9	0.2	0.0
B	BT	0.0	0.2	0.2	13.30	3.1	11.9	0.5
E	EM	19.9	22.2	20.2	4.99	0.0	3.1	11.2
E	IC	4.3	6.1	5.0	3.02	0.0	1.9	2.2
M	MM	0.2	1.6	1.6	10.97	0.0	9.8	2.8
R	HT	0.0	0.7	0.0	4.98	4.4	4.6	0.1
S1	SK	0.0	0.0	0.0	0.01	14.7	2.1	0.0
S2	MS	10.3	11.5	10.5	5.83	0.0	7.5	13.8
S3	SH	16.6	18.3	16.9	2.79	0.0	2.2	6.6
S4	DK	5.5	6.4	5.7	0.46	0.0	0.8	0.8
S5	MS	0.0	0.0	0.0	0.00	5.0	2.9	0.0
Total ship		5.3 1/	6.0 2/	5.6 1/	85.01 2/	11.5 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.23

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL WORK PACKAGES AND SHIPBOARD SCHEDULING, SIMULATION E

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	20.0 (0)	25.6 (+3)	22.9 (-3)	68.5 (0)
3-10	8.6 (0)	**	--	8.6 (0)
>10	22.9 (0)	--	--	22.9 (0)
Total	51.5 (0)	25.7 (+3)	22.9 (-3)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 5.6% EOC deferral, 11.5% basal slack.

TABLE 4.24

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING, SIMULATION E

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	59.9 (+17)	5.7 (+6)**	5.6 (+6)	71.3 (+29)
1-5	8.6 (-17)	2.9 (-6)	14.3 (0)	25.8 (-23)
>5	--	--	2.9 (-6)	2.9 (-6)
Total	68.5 (0)	8.6 (0)	22.9 (0)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 5.6% EOC deferral, 0.7% maximum minus minimum deferral.

TABLE 4.25

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING, SIMULATION E*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Executive	3 (0)	13 (+1)	1:4.3
Navigation/ Operations	16 (0)	5 (0)	1:0.3
Weapons/Air	29 (0)	24 (+1)	1:0.9
Engineering	36 (0)	37 (+1)	1:1.1
Supply/Medical	16 (0)	21 (-3)	1:1.3
Total ship, thou man-hours	2,503 (0)	140 (-6)	--

* Numbers in parentheses indicate the change from Simulation D.

** Rounded to nearest integer.

D. Similarly, the maximum number of billets needed to eliminate deferral went from 196.90 for Simulation D to 85.01 for Simulation E, and, as shown in Table 4.24, there was a dramatic change in the percentage of work centers that had less than a 1% difference between the maximum and minimum deferral. All of these factors reflect the significant benefits that would arise from scheduling.

4.31 The process used to determine the work-load scheduling associated with each work center spread the work load so that the work load/capability mismatch for each work center was approximately constant for all phases. The major benefit of the process is that a more accurate picture of the capability/work load imbalance expected for a work center may be obtained by observing the imbalance existing at any point in time, since wide fluctuations in the imbalance generally do not occur over the OPSKED. This benefit is clearly shown in the following example. In Simulation D, the minimum, maximum and EOC deferrals (as a percentage of total work load) for Work Center OE ET were 10.0%, 20.0% and 12.6%, respectively. Suppose that the work center (without the benefit of a tool such as the SWL algorithm) attempted to apply alternatives to reduce the work-center deferral. Alternatives considered might consist of those evaluated in this report (such as work-load transfer to other work centers) or might include those requiring outside assistance (such as transfer of work load to an IMA or depot). The first question to arise would be how much work load must be transferred. The answer would depend on the portion of the OPSKED being considered. On the average, 12.6% of the total work load would have to be transferred; over portions of the OPSKED, however, only 10.0% would have to be transferred, while over other portions, 20.0% must be transferred to avoid deferral problems. Now consider the same work center, but assume that it has been given

a tool by which it may schedule its work in the manner tested in this simulation. The minimum, maximum and EOC deferrals would be 6.0%, 13.9% and 12.6%, respectively. It would now be known that the deferral at any point during the cycle was reasonably representative of the average (12.6%) deferral, and a better perspective as to the most desirable action would be achieved.

Simulation E Summary

4.32 For the FF-1052 class, judicious shipboard scheduling would be expected to result in a slight decrease in deferral. The major benefit, however, would arise through the manner in which the elimination of wide fluctuations in deferral over the OPSKED would facilitate planning and reduce the possibility of arriving at erroneous conclusions based on a single point-in-time observation of the work-load/capability imbalance for a given work center.

SIMULATION F, FORMAL ORGANIZATIONAL CONCEPTS

4.33 The FF-1052 class Simulation F was conducted by applying Alternative 6, formal organizational concepts, to the class baseline data and running the SWL algorithm against the resultant data base.

Sensitivity Parameters

4.34 As discussed in Section III, Alternative 6 affects the number and composition of work centers, work-center manning (although total ship manning is not affected), formal organization, work loads associated with each work center, training associated with each work center and leave (during LVUPK phases).

The way most of these parameters change as a result of Alternative 6 was described in Section III. The new training and leave during LVUPK values are presented in Table 4.26.

Simulation F Results

4.35 Table 4.27 displays the results of Simulation F, work center by work center. Tables 4.28 through 4.30 summarize the results in the same manner used for other simulations.

4.36 Analysis of Results. For the total ship, Simulation F's EOC deferral is 6.1%, up slightly from the 5.3% present in the baseline. Basal slack also increased slightly from 12.3% in the baseline to 13.0% for this simulation. The range of deferral experienced over the course of the OPSKED has increased somewhat, as exhibited by the increase in the percentage of work centers having greater than 5% maximum minus minimum deferral, the increase in shipwide maximum minus minimum deferral to 1.4% in Simulation F from the baseline value of 1.3%, and the increase in the maximum number of billets needed to eliminate deferral to 201.01 from the baseline value of 193.53.

4.37 These changes, however, are not indicative of the true impact of the alternative tested. In Table 4.31, Simulation F and baseline values are displayed, with results aggregated into engineering and nonengineering departmental groupings. From this table it can be seen that the relative work loads (and in fact actual man-hours of work load) for each group remained constant between the baseline and Simulation F. However, the EOC deferral as a percentage of the ship EOC deferral and, specifically, the man-hours of EOC deferral for each group changed considerably when the new, formal organization was applied. Shipwide, an increase of 21,000 man-hours of EOC deferral occurred due to the new, formal organization. For the nonengineering departments, however, a decrease in EOC deferral

TABLE 4.26

FF-1052 CLASS TRAINING AND LEAVE (DURING LVUPK)--
SIMULATION F

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
SC1	QM	15.57	3.71	10.10	40.46	3,076.79
SC1	SM	16.06	3.30	3.00	43.34	32.00
SC2	ET	13.32	5.09	0.56	90.67	429.33
SC2	RM	16.21	3.48	0.80	21.55	400.66
SC3	BM	15.57	3.65	6.03	38.54	1,779.20
CS1	ET	13.32	5.09	0.56	90.67	429.33
CS1	EW	15.28	2.81	0.77	68.00	1,053.33
CS1	OS	13.29	8.20	1.54	22.67	3,102.67
CS1	STG	15.11	4.98	2.42	37.33	637.34
CS2	FTG	15.27	4.72	1.02	44.95	525.34
CS2	FTM	15.38	4.26	0.75	40.38	278.67
CS2	GMG	15.72	4.82	2.64	17.07	629.33
CS2	TM	14.79	5.78	1.33	42.67	194.67
E1	BT	16.30	3.92	2.84	15.06	1,677.06
E1	EM	14.72	4.66	0.69	16.77	555.43
E1	HT	13.49	6.90	1.16	72.89	924.57
E1	IC	14.60	4.62	0.68	19.74	597.60
E1	MM	13.64	4.42	5.32	76.21	4,399.21
E2	BT	16.30	3.92	0.99	15.06	583.33
E2	EM	14.72	4.66	0.92	16.77	740.57
E2	EN	12.89	4.97	0.91	23.11	738.67
E2	HT	13.49	6.90	1.54	72.89	1,232.75
E2	IC	14.60	4.62	0.46	19.74	398.40
E2	MM	13.64	4.41	2.10	77.52	1,755.80
E2	MR	15.26	3.91	0.32	10.67	186.67
S1	DK	16.13	3.60	0.12	34.67	2.67
S1	HM	15.32	4.89	0.55	16.01	104.00
S1	MA	18.21	0.00	0.00	0.00	0.00
S1	PC	16.63	3.35	0.08	10.67	72.67
S1	PO	18.21	0.00	0.00	0.00	0.00
S1	PN	16.12	3.60	0.00	37.27	56.34
S1	SK	16.00	2.69	0.53	30.94	64.00
S1	YN	15.59	3.44	1.01	64.22	134.00
S2	MS	15.59	3.40	7.96	31.60	1,995.68
S2	SH	15.68	3.85	2.01	21.34	448.01

TABLE 4.27

FF-1052 CLASS STATUS WITH FORMAL ORGANIZATIONAL CONCEPTS--SIMULATION F

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
SC1	QM	0.0	1.7	0.4	21.90	3.8	10.1	0.8
SC1	SM	0.0	0.3	0.0	0.41	13.5	2.2	0.0
SC2	ET	0.1	10.0	2.2	5.18	4.5	1.0	0.4
SC2	RM	0.0	0.0	0.0	0.00	7.2	4.6	0.0
SC3	BM	11.8	13.2	12.6	19.83	0.0	7.2	14.9
CS1	ET	19.5	30.5	21.6	8.31	0.0	1.3	4.5
CS1	EW	0.0	0.8	0.0	1.05	15.7	1.0	0.0
CS1	OS	0.0	0.0	0.0	-8.89	4.0	4.0	0.0
CS1	STG	0.0	0.3	0.0	2.09	5.4	5.3	0.0
CS2	FTG	0.0	1.8	0.3	4.44	16.7	1.9	0.1
CS2	FTM	0.0	0.0	0.0	-2.78	15.5	0.7	0.0
CS2	GMG	0.0	1.7	0.4	6.75	0.9	3.0	0.2
CS2	GMT	0.0	0.0	0.0	-0.63	16.0	1.3	0.0
CS2	TM	13.2	16.6	14.3	3.49	0.0	0.8	2.0
E1	BT	0.0	1.2	0.1	14.23	4.1	9.0	0.2
E1	EM	0.0	5.2	0.0	3.52	10.6	1.0	0.0
E1	HT	0.0	3.7	1.0	7.17	14.4	1.9	0.3
E1	IC	0.0	0.4	0.0	0.11	13.8	1.0	0.0
E1	MM	0.0	0.5	0.0	5.90	4.7	7.2	0.0
E2	BT	0.0	3.2	0.0	1.69	4.3	2.8	0.0
E2	EM	33.4	34.6	34.1	6.65	0.0	2.1	11.7
E2	EN	39.0	44.5	40.1	4.50	0.0	1.0	6.7
E2	HT	3.0	8.6	8.0	4.97	0.0	2.8	3.7
E2	IC	26.2	33.3	27.7	4.85	0.0	0.9	4.3
E2	MM	28.2	34.9	29.5	27.65	0.0	5.3	25.8
E2	MR	0.0	1.9	0.4	0.71	8.2	0.3	0.0
S1	DK	0.7	2.2	1.6	2.09	0.0	0.8	0.2
S1	HM	0.0	1.2	0.0	1.06	6.2	0.7	0.0
S1	MA	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
S1	PC	0.0	1.3	0.1	0.60	8.2	0.4	0.0
S1	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
S1	PN	0.0	1.9	0.0	1.36	3.4	1.2	0.0
S1	SK	0.0	0.0	0.0	0.14	14.7	2.1	0.0
S1	YN	18.8	21.9	19.8	7.82	0.0	1.9	6.3
S2	MS	5.4	7.0	6.8	25.99	0.0	10.4	11.7
S2	SH	15.8	17.7	16.6	7.15	0.0	2.2	6.1
Total ship		5.6 1/	7.0 2/	6.1 1/	201.61 2/	13.0 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.28

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH FORMAL ORGANIZATIONAL CONCEPTS, SIMULATION F

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	19.4 (-4)	27.8 (+5)	22.2 (-3)	69.4 (-2)
3-10	5.6 (0)	**	--	5.6 (0)
<10	25.0 (+2)	--	--	25.0 (+2)
Total	50.0 (-2)	27.8 (+5)	22.2 (-3)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 6.1% EOC deferral, 13.0% basal slack.

TABLE 4.29

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH FORMAL ORGANIZATIONAL CONCEPTS, SIMULATION F

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	< 3	3-10	>10	Total
<1	33.3 (-7)	--	--	33.3 (-7)
1-5	30.6 (-1)	2.8 (-3)**	13.9 (0)	47.3 (-4)
>5	5.5 (+6)	2.8 (+3)	11.1 (+2)	19.4 (+11)
Total	69.4 (-2)	5.6 (0)	25.0 (+2)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 6.1% EOC deferral, 1.4% maximum minus minimum deferral.

TABLE 4.30

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH FORMAL ORGANIZATIONAL CONCEPTS, SIMULATION F

Department	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Ship Control	25	16	1:0.6
Combat Systems	19	7	1:0.4
Engineering (E1)	20	1	1:0.1
Engineering (E2)	16	52	1:3.25
Support	20	24	1:1.2
Total ship, thou man-hours	2,461	150	--

* Rounded to nearest integer.

TABLE 4.31

WORK LOAD AND DEFERRAL COMPARISON--SIMULATION F VERSUS BASELINE

Department	Work Load as % of Total Ship		EOC Deferral as % of Total Ship		EOC Deferral, thou man-hours	
	Simulation F	Baseline	Simulation F	Baseline	Simulation F	Baseline
Engineering	36	36	53	35	79.50	45.15
Nonengineering	64	64	47	65	70.50	83.85
Total ship	100	100	100	100	150	129

of over 13,000 man-hours occurred, while for the Engineering Department there was an increase of nearly 34,000 man-hours.

4.38 The reason for this wide difference between the effects observed for the two groups is found in the manner in which the new, formal organization manifested itself in each group. For the baseline, 35 work centers were present: 8 engineering and 27 nonengineering (where baseline Work Center A YN is treated as a nonengineering work center). As a result of Alternative 6, 36 work centers were constructed: 12 engineering and 24 nonengineering. The increase in engineering work centers and decrease in nonengineering work centers are associated directly with the changes in deferral. For example, for the baseline, the two MS work centers accounted for approximately 20,800 man-hours of EOC deferral, while the single Simulation F MS work center accounted for roughly 17,600 man-hours of deferral. The merger of the MS's into a single work center has resulted in an improvement relative to total work accomplished. On the other hand, the construction of two IC work centers work for this simulation resulted in an increase in IC-related deferral of 3,900 man-hours. Similarly the formation of two EM work centers where only one existed in the baseline has resulted in an increase in EM-related deferral of approximately 3,400 hours.

4.39 The increase in deferral due to the splitting of a single work center into two work centers arises as a result of the difficulty encountered in determining the work load to be assigned to each of the new work centers. The process used to construct the Simulation F engineering work centers, for example, was based on first assigning all OPMAN work load to the E1 (operator) work centers, setting the E1 work-center manning at the level necessary to support the OPMAN requirements, and

then allocating additional FM and OUS work load to each work center, based on the capability of the work center to accomplish the work load. Since both the OPMAN and capability of each work center varied from phase to phase within the cycle, an optimum "match" between the work load and capability for each E1 work center could not be achieved without using alternatives such as shipboard scheduling and/or phase-dependent discrete work-load transfers. Since the objective was to evaluate the impact of Alternative 6 alone in this simulation, the introduction of other alternatives was avoided whenever possible. The FM and OUS work load assigned to E1 work centers was therefore limited to a single average hour-per-week amount for each category, and the total FM and OUS assigned was determined based on the objective of producing near-zero EOC deferral for each E1 work center. For each E2 (maintenance) work center, the manning level was set at the total rating manning for the ship minus that portion of the total assigned to the E1 counterpart. For example, the baseline HT manning was 14; 6 HTs were assigned to E1 HT leaving 8 for assignment to E2 HT. E2 work-center work loads were set at 100% of the PM and CM associated with rating plus the residual FM and OUS (i.e., that amount of FM and OUS not assigned to the E1 counterpart).

4.40 As shown by Table 4.27, the E1 work centers did in fact have zero or near-zero EOC deferral, even though they each exhibited some deferral during various phases of the OPSKED. The price paid for the zero or small EOC deferral was the creation of basal slack. The basal slack represents capability, which, prior to the splitting of work centers, had been available to keep the total rating-associated deferral down to its baseline level. With Alternative 6 alone applied, however, the capability cannot be used where needed (i.e., in the E2 work-center counterpart), and, hence, additional deferral results.

Table 4.30 shows the net result: 52% of the total ship EOC deferral is concentrated in the E2 (engineering) division, with only 1% occurring in the E1 (operator) divisions.

4.41 Notwithstanding the adverse impact of Alternative 6 relative to Engineering Department deferral, certain positive aspects of the alternative exist:

a. Nonengineering department deferral was reduced

b. The organization alignment has resulted in a high concentration of deferral in five Engineering Department divisions: E2 EM, E2 EN, E2 HT, E2 IC, and E2 MM. PM and CM constitute, on the average, more than 50% of the work load assigned to these five work centers, while the PM and CM assigned to all other work centers that have significant EOC deferral amounts to only about 10% of the total PM and CM on the ship. Hence, addressing the problems of the five work centers would probably equate to addressing 90% of the PM/CM deferral problems for the ship.

Simulation F Summary

4.42 A fragmentation of work centers tends to increase deferral problems, while merging work centers has the opposite effect. The fragmentation may, however, lead to a better definition of not only which work centers would experience deferral problems, but also the nature of work that would potentially be deferred. In view of this, the application of other alternatives (in addition to a formal reorganization) may be facilitated. For example, during the test period on the DE-1082, [2/] additional

[2/] Results were reported in a letter from the Commanding Officer, USS ELMER MONTGOMERY (DE-1082), DE-1082/RSS:al, 5400 ser 151, 3 May 1973.

alternatives were applied subsequent to the reorganization of the Engineering Department work centers. These alternatives included scheduling based on the capability versus work-load patterns of each work center (i.e., Alternative 5, shipboard scheduling), frequent shifting of personnel between the operator and maintainer divisions (analogous to and producing similar results as Alternative 1, work-load transfers), assigning FM to small teams (i.e., Alternative 2, new FM concepts), and reducing at-sea OPMAN (an alternative predicated on extended watchstation training and peak watchstander proficiency and, hence, used only intermittently by the DE-1082 when few new watchstanders were being indoctrinated and proficiency levels had not dropped due to lengthy in-port periods). The selection and application of these additional alternatives (except for the OPMAN reduction, which was attempted based on the rationale that certain features of the engineering plant were conducive to reduced engineering OPMAN requirements) was primarily possible as a direct result of the new engineering organization quickly allowing the true capability-versus-imbalance problems to be identified. Since the work-center work loads were readily identified as either OPMAN or maintenance, appropriate solutions could be tailored to each work center's problems. The application of these additional alternatives caused the favorable results reported by the DE-1082.

SIMULATION G, FUNCTIONALLY BASED FORMAL ORGANIZATION

4.43 Simulation G was conducted by applying Alternative 7, a functionally based formal organization, to the FF-1052 class baseline data and running the SWL algorithm against the resultant data base.

Sensitivity Parameters

4.44 The changes in work centers, work-center manning and work loads required to simulate the functionally based formal organization were described in Section III. The redistribution of manning arising from the new organization required that work-center training be recomputed. The revised training breakdown required new LVUPK leave values to be calculated. The results of these computations are shown in Table 4.32.

Simulation G Results

4.45 Table 4.33 shows the results of Simulation G, work center by work center. Tables 4.34 through 4.36 display summary information concerning the simulation.

4.46 Analysis of Results. The total EOC deferral for the ship is 12.7% of the total work load, compared to 5.3% in the baseline. Basal slack has also risen to 22.7% from the baseline value of 12.3%. In general, all indicators point to the fact that, relative to expected deferral, the functionally based organization would result in more, rather than fewer, problems.

4.47 The rise in deferral is attributable to the same factor addressed in the FF-1052 class Simulation F results analysis: an increase in the number of work centers. For the baseline, 35 work centers existed; with the functionally based formal organization applied, 41 work centers are present. As discussed in some detail with reference to FF-1052 class Simulation F, the formation of additional work centers results in an increase in deferral if additional alternatives are not simultaneously applied. The effect is caused by the inefficiencies resulting from the traditional handling of work load (e.g., by average weekly hours).

TABLE 4.32

FF-1052 CLASS TRAINING AND LEAVE (DURING LVUPK)--FUNCTIONALLY BASED FORMAL ORGANIZATION

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
OA	PY	15.53	3.43	0.00	62.22	0.00
OB	CD	15.66	3.63	3.42	42.42	642.06
OC	RE	16.21	3.48	0.55	21.55	277.38
OD	EW	15.28	2.81	0.66	68.00	902.85
OE	OS	13.29	8.20	1.12	22.67	2,246.76
OF	STG	15.11	4.98	1.91	37.33	503.16
OG	FTM	15.38	4.26	0.64	40.38	238.86
OH	GMT	15.18	4.49	2.84	28.17	771.08
OI	MB	15.04	4.16	6.74	44.00	4,610.84
OJ	HT	13.49	6.90	0.58	72.89	462.28
OK	EI	14.67	4.64	1.37	18.26	1,153.03
OL	SN	15.32	4.37	12.34	35.53	3,800.44
OM	FN	14.27	4.91	2.34	60.09	1,828.65
MA	CD	15.50	3.77	1.71	41.47	544.46
MB	RE	14.77	4.29	0.25	56.11	173.93
MC	EW	15.28	2.81	0.11	68.00	150.48
MD	OS	13.29	8.20	0.05	22.67	106.99
ME	STG	15.11	4.98	0.51	37.33	134.18
MF	EF	14.01	4.81	0.48	73.91	326.03
MG	FTG	15.27	4.72	0.51	44.95	262.67
MH	GMT	15.18	4.49	0.47	28.17	128.51
MI	GMG	15.72	4.82	2.64	[illegible]7.07	629.33
MJ	TM	14.79	5.78	1.33	42.67	194.67
MK	MB	14.90	4.18	3.25	47.82	2,438.19
ML	EN	12.89	4.66	0.46	23.11	738.67
MM	MR	15.26	3.91	0.32	10.67	186.67
MN	HT	13.49	6.90	1.35	72.89	1,078.66
MO	EI	14.67	4.65	1.38	17.76	1,138.97
MP	SN	14.94	4.51	3.28	49.32	1,434.42
MQ	FN	13.49	6.90	0.19	72.89	154.09
MR	PO	18.21	0.00	0.00	0.00	0.00
MS	PY	15.28	3.43	0.34	62.22	44.67
SA	HM	15.32	4.89	0.55	16.01	104.00
SB	SK	16.00	2.69	0.38	30.94	45.71
SC	DK	16.13	3.60	0.12	34.67	2.67
SD	MS	15.47	3.40	6.43	31.60	1,611.90
SE	SH	15.68	3.85	2.01	21.34	448.01
SF	PY	15.95	3.52	0.67	51.75	126.89
SG	PC	16.63	3.35	0.08	10.67	72.67
SH	MA	18.21	0.00	0.00	0.00	0.00
SI	SN	15.78	3.24	1.58	32.01	411.48

TABLE 4.33

FF-1052 CLASS STATUS WITH FUNCTIONALLY BASED FORMAL ORGANIZATION--SIMULATION G

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
OA	PY	0.0	0.0	0.0	-0.13	46.8	0.2	0.0
OB	CD	0.0	0.5	0.0	0.88	10.6	3.4	0.0
OC	RE	0.0	0.0	0.0	-0.48	10.5	2.8	0.0
OD	EW	0.0	0.0	0.0	-1.37	18.3	0.4	0.0
OE	OS	0.0	0.0	0.0	-8.26	5.5	3.1	0.0
OF	STG	0.0	0.0	0.0	-4.97	6.8	3.3	0.0
OG	EF	0.0	0.0	0.0	-4.13	17.8	0.2	0.0
OH	GMT	0.0	0.0	0.0	-1.77	18.2	0.4	0.0
OI	MB	0.0	0.0	0.0	-1.67	2.8	10.4	0.0
OJ	HT	0.0	0.7	0.0	0.43	39.6	0.4	0.0
OK	EI	0.0	2.9	0.0	2.50	3.6	2.2	0.0
OL	SN	0.0	0.3	0.0	4.20	2.7	11.0	0.0
OM	FN	12.7	17.8	13.5	17.34	0.0	5.6	5.9
MA	CD	0.0	4.3	1.2	6.32	2.7	1.8	0.2
MB	RE	15.7	21.4	17.1	3.94	0.0	0.9	1.2
MC	EW	0.0	1.2	0.0	0.47	9.0	0.3	0.0
MD	OS	0.0	0.6	0.0	0.20	28.2	0.2	0.0
ME	STG	0.0	2.1	0.6	3.71	5.9	1.4	0.1
MF	EF	0.0	3.9	1.1	3.44	6.8	1.0	0.1
MG	FTG	0.0	1.3	0.0	1.41	22.7	0.8	0.0
MH	GMT	53.0	55.5	55.1	1.68	0.0	0.8	3.4
MI	GMG	0.0	0.8	0.0	2.41	14.0	2.4	0.0
MJ	TM	0.0	1.7	0.2	1.29	18.7	0.6	0.0
MK	MB	0.4	2.3	1.0	12.43	0.6	6.8	0.6
ML	EN	23.7	31.1	25.2	3.60	0.0	0.8	1.7
MM	MR	0.0	0.0	0.0	0.00	34.5	0.2	0.0
MN	HT	0.0	0.4	0.0	1.28	14.8	1.9	0.0
MO	EI	8.6	11.8	9.7	7.68	0.0	2.3	1.8
MP	SN	45.3	49.8	46.3	52.45	0.0	9.3	34.0
MQ	FN	93.6	94.2	93.7	37.68	0.0	5.1	37.8
MR	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
MS	PY	0.0	1.2	0.0	0.09	31.9	0.3	0.0
SA	HM	0.0	1.2	0.0	1.06	3.2	0.7	0.0
SB	SK	0.0	0.1	0.0	0.21	20.3	1.5	0.0
SC	DK	0.0	1.6	0.3	1.56	5.6	0.8	0.0
SD	MS	0.0	1.7	0.4	15.98	1.1	7.8	0.3
SE	SH	2.7	4.2	3.6	5.06	0.0	1.9	0.6
SF	PY	8.7	11.9	9.7	6.32	0.0	1.7	1.3
SG	PC	0.0	0.0	0.0	0.08	24.2	0.3	0.0
SH	MA	0.0	0.0	0.0	-0.09	38.5	0.3	0.0
SI	SN	30.6	32.4	31.3	16.78	0.0	4.4	11.0
Total Ship		12.1 1/	14.4 1/	12.7 1/	212.48 2/	22.7 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.34

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH FUNCTIONALLY BASED FORMAL ORGANIZATION, SIMULATION G

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	17.1 (-6)	24.4 (+1)	34.1 (+9)	75.6 (+4)
3-10	7.3 (+2)	--	--	7.3 (+2)
>10	17.1 (-6)	--	**	17.1 (-6)
Total	41.5 (-10)	24.4 (+1)	34.1 (+9)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 12.7% EOC deferral, 22.7% basal slack.

TABLE 4.35

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH FUNCTIONALLY BASED FORMAL ORGANIZATION, SIMULATION G

Maximum Minus Minimum Deferral, %	Percentage of Work Centers			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	46.3 (+6)	--	2.5 (+3)	48.8 (+9)
1-5	29.3 (-2)	7.3 (+2)	7.3 (-7)**	43.9 (-7)
>5	--	--	7.3 (-2)	7.3 (-2)
Total	75.6 (+4)	7.3 (+2)	17.1 (-6)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 12.7% EOC deferral, 2.3% maximum minus minimum deferral.

TABLE 4.36

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH FUNCTIONALLY BASED FORMAL ORGANIZATION, SIMULATION G

Department	Division	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Operations	Control, detection & delivery	14	0	--
	Hull, mechanical & electrical	30	6	1:0.2
Maintenance	Control, detection & delivery	10	5	1:0.5
	Hull, mechanical & electrical	27	76	1:2.8
Support	All	19	13	1:0.7
Total ship, thou man-hours**	--	2,461	311 (+182)	--

* Rounded to nearest integer.

** Numbers in parentheses indicate the change from the baseline.

4.48 Although the functionally based formal organization applied alone will result in a significant increase in deferral, the manner in which the work load is distributed facilitates analysis of the deferral problems and, therefore, would provide a framework in which additional alternatives could be applied effectively. Table 4.37 shows the EOC deferral as a percent of total EOC deferral for each work center exhibiting EOC deferral in Simulation G. For each work center, a work category associated with the deferral is identified. The work categories associated with the deferral are based on the assumptions that all of the deferral associated with a work center is composed of the predominant category of work assigned to the work center, but no OPMAN is deferred. In fact, for each work center in Table 3.2 (except for OM FN), the work category shown generally represents over 85% of the work load for the work center. For OM FN, OUS constitutes all of the non-OPMAN work load. With these two assumptions and in view of the way various categories of work are distributed throughout the ship, certain bounds may be set relative to the EOC deferral. For the FF-1052 class with the functionally based formal organization applied, these bounds are as follows:

- PM/CM represents a maximum of 9.1% of the EOC deferral
- FM represents a maximum of 82.8% and a minimum of roughly 71% of the EOC deferral
- OUS represents a minimum of 8.1% and a maximum of about 29% of the EOC deferral.

Simulation G Summary

4.49 The application of a functionally based formal organization alone would result in a significant increase in EOC deferral.

TABLE 4.37

EOC DEFERRAL AS PERCENT OF TOTAL EOC DEFERRAL, BY WORK CENTERS AND WORK CATEGORY-- FF-1052 CLASS, SIMULATION G

Work Center		Work Category	Percent of Total EOC Deferral
Division	Rating		
MP	SN	FM	34.0
MQ	FN	FM	37.8
SI	SN	FM	11.0
MA	CD	PM/CM	0.2
MB	RE	PM/CM	1.2
ME	STG	PM/CM	0.1
MF	EF	PM/CM	0.1
MH	GMT	PM/CM	3.4
MK	MB	PM/CM	0.6
ML	EN	PM/CM	1.7
MO	EI	PM/CM	1.8
OM	FN	OUS	5.9
SD	MS	OUS	0.3
SE	SH	OUS	0.6
SF	PY	OUS	1.3

However, the manner in which work load and deferral would be distributed throughout the ship would facilitate analysis and, with only limited assumptions required, allow bounds to be set relative to the magnitude of the deferral existing in each work category.

SIMULATION H, NOTIONAL SMD

4.50 The FF-1052 class Simulation H was conducted by applying Alternatives 1 through 5 and Alternative 7 to the FF-1052 class baseline data and running the SWL algorithm on the resultant data base. The modified data base also served as the foundation for the notional ship manpower document (SMD) for the FF-1052 class. Since the FF-1052 class notional SMD (delivered under separate cover) contains a detailed description of work loads, organization, manning levels and other parameters as they appeared in the modified data base used for Simulation H, the discussions in this report will be limited to defining the way in which the notional SMD/Simulation H data base was developed; redundant displays of the actual work loads, manning, etc., will not be provided.

Sensitivity Parameters

4.51 Sensitivity parameters were changed through a series of steps equating to the application of each alternative to be included in the simulation. The steps followed were:

a. First, Alternative 7, a functionally based formal organization, was applied. Since the alternative had been applied alone for FF-1052 class Simulation G, the Simulation G data base was, in fact,

used as the basis for the application of the remainder of the alternatives.

b. Alternative 4, work packages, was applied. The notional FF-1052 class work package described in Appendix E was used; however, the TAV/SRA work loads and average hours-per-week PM and CM reductions were reaggregated as required to fit the new formal organization.

c. Alternative 3, reliability-centered maintenance principles, was applied by reducing the PM work load for each work center (now including the notional work package) by 37.9%.

d. Alternative 2, new FM concepts, was applied by reducing the FM work loads by 30% and assigning an additional 0.125-hr/man/wk training to those work centers performing FM. Note that the construction of FM teams had already been accomplished through the application of the functionally based formal organization.

e. Based on estimates of the deferral patterns that would exist with the application of the alternatives listed above, discrete work-load transfers were identified and appropriate changes to work-center work loads were made. In general, these shifts centered on Work Centers OL SN, OM FN, MP SN, MQ FN and SI SN, support work centers for each department. For Work Center MQ FN, non-rating-sensitive PM, initially derived from MM, BT and HT work loads during the construction of the functionally based formal organization, was transferred to Work Centers MK MB and MN HT. Non-rating-sensitive OUS, originally

derived from HT work loads, was transferred to MN HT. For Work Center OM FN, OUS originally derived from MM and BT work loads was transferred to Work Center OI MB. FM, initially assigned to Work Centers MP SN and SI SN, was transferred to Work Center OL SN (thereby creating another FM team).

f. Based on estimates of the deferral patterns that would occur as a result of Steps a through e above, Alternative 5, shipboard scheduling, was applied using the process discussed in Section III.

g. Estimates of the work-load-versus-capability imbalances still remaining were made and manning shifted among work centers as follows:

1. One EI billet (EM/IC) to Work Center OK EI from Work Center MO EI
2. One HT billet to Work Center OJ HT from Work Center MN HT
3. Four MB billets (MM/BTs) to Work Center MQ FN from Work Center MK MB
4. One GMG billet from Work Center MI GMG converted to a GMT billet and added to Work Center MH GMT
5. One FTG billet from Work Center MG FTG converted to an STG billet and added to Work Center OF STG
6. One GMG billet from Work Center MI GMG and one CD (SM/QM/BM) billet from Work Center MA CD converted to two billets for Work Center MQ FN.

4.52 As a result of the manning changes and new FM concepts, it was necessary to compute new work-center training and LVUPK values. The results of the calculations are shown in Table 4.38.

Simulation H Results

4.53 Table 4.39 shows the results, work center by work center, for the FF-1052 class with the notional SMD data applied. Tables 4.40 through 4.42 summarize information from Table 4.39 and show the changes that occurred relative to the baseline values.

4.54 Analysis of Results. Shipwide, the expected EOC deferral has been reduced from the baseline value of 5.3% to 1.9%, maximum deferral reduced from 6.2% to 2.2%, and minimum deferral lowered from 4.9% to 1.8%. The maximum number of billets needed to eliminate deferral has been lowered to 40.32 from the baseline level of 193.83, and shipwide maximum minus minimum deferral has dropped from the baseline value of 1.3% to 0.4%. Basal slack has risen, however, from the baseline level of 12.3% to 19.2%. Over 88% of the work centers have less than 3% EOC deferral and over 86% have less than 1% maximum minus minimum deferral.

4.55 As in the case of the FF-1052 class Simulation G, by assuming that all of the deferral associated with a work center is composed of the predominant category of work assigned to the work center and that no OPMAN is deferred, bounds may be established relative to the categories of work associated with the deferral. Table 4.43 displays the work centers that exhibited EOC deferral, the predominant work category associated with each work center, and the percentage of the total EOC deferral residing in each work center. Using this table and the

TABLE 4.38

FF-1052 CLASS TRAINING AND LEAVE (DURING LVUPK)--NOTIONAL SMD, SIMULATION H

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
OA	PY	15.53	3.43	0.00	62.22	0.00
OB	CD	15.66	3.63	3.42	42.42	642.06
OC	RE	16.21	3.48	0.55	21.55	277.38
OD	EW	15.28	2.81	0.66	68.00	902.85
OE	OS	13.29	8.20	1.12	22.67	2,246.76
OF	STG	15.11	4.98	2.04	37.33	536.71
OG	FTM	15.38	4.26	0.64	40.38	238.86
OH	GMT	15.18	4.49	2.84	28.17	771.08
OI	MB	15.04	4.16	6.24	44.00	4,610.84
OJ	HT	13.49	6.90	0.77	72.89	616.38
OK	EI	14.67	4.64	1.61	18.04	1,338.97
OL	SN	15.32	4.37	12.34	35.53	3,800.44
OM	FN	14.27	4.91	2.34	60.09	1,828.65
MA	CD	15.47	3.80	1.28	41.96	417.37
MB	RE	14.77	4.29	0.25	56.11	173.93
MC	EW	15.28	2.81	0.11	68.00	150.48
MD	OS	13.29	8.20	0.05	22.67	106.99
ME	STG	15.11	4.98	0.38	37.33	100.63
MF	EF	14.01	4.81	0.48	73.91	326.03
MG	FTG	15.27	4.72	0.34	44.95	175.11
MH	GMT	15.18	4.49	0.95	28.17	257.03
MI	GMG	15.72	4.82	1.98	17.07	472.00
MJ	TM	14.79	5.78	1.33	42.67	194.67
MK	MB	14.88	4.18	2.58	48.26	1,935.97
ML	EN	12.89	4.66	0.46	23.11	738.67
MM	MR	15.26	3.91	0.32	10.67	186.67
MN	HT	13.49	6.90	1.16	72.89	924.57
MO	EI	14.67	4.65	1.15	17.96	953.83
MP	SN	14.95	4.51	2.11	49.32	922.13
MQ	FN	15.01	4.74	1.70	42.09	901.21
MR	PO	18.21	0.00	0.00	0.00	0.00
MS	PY	15.28	3.43	0.34	62.22	44.67
MT	RE	14.95	4.51	0.23	49.32	102.46
MU	FTG	14.95	4.51	0.94	49.32	409.83
SA	HM	15.32	4.89	0.55	16.01	104.00
SB	SK	16.00	2.69	0.38	30.94	45.71
SC	DK	16.13	3.60	0.12	34.67	2.67
SD	MS	15.47	3.40	6.43	31.60	1,611.90
SE	SH	15.68	3.85	2.01	21.34	448.01
SF	PY	15.95	3.52	0.67	51.75	126.89
SG	PC	16.63	3.35	0.08	10.67	72.67
SH	MA	18.21	0.00	0.00	0.00	0.00
SI	SN	15.68	3.25	2.67	32.14	420.85

TABLE 4.39

FF-1052 CLASS STATUS--NOTIONAL SMD, SIMULATION H

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
OA	PY	0.0	0.0	0.0	-0.13	46.8	0.2	0.0
OB	CD	0.0	0.6	0.0	0.74	8.5	3.8	0.0
OC	RE	0.0	0.0	0.0	-0.25	10.6	3.1	0.0
OD	EW	0.0	0.0	0.0	-1.37	18.3	0.5	0.0
OE	OS	0.0	0.0	0.0	-0.40	5.5	3.6	0.0
OF	STG	0.0	0.0	0.0	-5.48	6.5	3.6	0.0
OG	FTM	0.0	0.0	0.0	-4.13	17.8	0.2	0.0
OH	GMT	0.0	0.0	0.0	-1.77	18.2	0.4	0.0
OI	MB	0.0	0.0	0.0	0.00	18.2	12.2	0.0
OJ	HT	0.0	0.0	0.0	-0.16	30.2	0.5	0.0
OK	EI	0.0	0.0	0.0	0.45	15.2	2.4	0.0
OL	SN	0.0	0.5	0.0	9.66	2.7	14.5	0.0
OM	FN	0.0	3.2	0.7	11.49	2.1	5.2	2.1
MA	CD	0.0	1.0	0.5	0.97	0.1	1.6	0.4
MB	RE	0.6	2.6	1.3	1.91	0.4	0.8	0.6
MC	EW	0.0	0.6	0.0	0.21	25.8	0.3	0.0
MD	OS	0.0	0.0	0.0	-0.06	47.9	0.2	0.0
ME	STG	0.0	0.0	0.0	0.00	4.1	1.2	0.0
MF	EF	0.0	0.3	0.0	0.20	17.7	0.9	0.0
MG	FTG	0.0	0.8	0.0	0.28	5.8	0.7	0.0
MH	GMT	0.0	0.0	0.0	0.00	14.0	0.7	0.0
MI	GMG	0.0	0.0	0.0	-0.01	10.5	2.1	0.0
MJ	TM	0.0	0.0	0.0	-0.04	32.9	0.5	0.0
MK	MB	5.7	6.0	5.8	2.00	0.0	6.2	18.8
ML	EN	6.6	8.0	7.3	1.27	0.0	0.7	2.8
MM	MR	0.0	0.0	0.0	-0.01	13.7	0.3	0.0
MN	HT	0.0	0.4	0.0	0.28	6.6	2.0	0.0
MO	EI	9.1	10.7	9.6	1.75	0.0	2.1	10.5
MP	SN	1.5	1.7	1.5	0.60	0.0	3.6	2.9
MQ	FN	27.2	29.3	27.7	6.73	0.0	3.7	53.4
MR	PO	0.0	0.0	0.0	-0.09	47.0	0.2	0.0
MS	PY	0.0	0.0	0.0	-0.12	45.2	0.2	0.0
MT	SN	1.4	1.6	1.5	0.07	0.0	0.4	0.3
MU	SN	1.4	1.6	1.5	0.27	0.0	1.6	1.3
SA	HM	0.0	0.0	0.0	-0.09	14.9	0.7	0.0
SB	SK	0.0	0.0	0.0	-0.15	11.8	1.9	0.0
SC	DK	0.0	0.0	0.0	-0.01	5.2	0.8	0.0
SD	MS	0.1	0.2	0.2	0.14	0.0	8.6	1.2
SE	SH	0.0	0.2	0.0	0.52	0.0	2.0	0.1
SF	PY	0.0	0.4	0.0	0.94	2.9	1.7	0.0
SG	PL	0.0	0.2	0.0	0.08	24.2	0.3	0.0
SH	MA	0.0	0.0	0.0	-0.09	38.5	0.3	0.0
SI	SN	3.1	3.2	3.2	0.46	0.0	3.4	5.7
Total ship		1.8 1/	2.2 1/	1.9 1/	40.32 2/	19.2 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 4.40

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL SMD, SIMULATION H

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	25.6 (+3)	34.9 (+12)	27.9 (+2)*	88.4 (+17)
3-10	9.3 (+4)	--	--	9.3 (+4)
>10	2.3 (-21)	--	--	2.3 (-21)
Total	37.2 (-14)	34.9 (+12)	27.9 (+2)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 1.9% EOC deferral, 19.2% basal slack.

TABLE 4.41

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FF-1052 CLASS WITH NOTIONAL SMD, SIMULATION H

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	81.4 (+41)**	4.7 (+5)	--	86.1 (+46)
1-5	7.0 (-24)	4.6 (-1)	2.3 (-12)	13.9 (-37)
>5	--	--	0.0 (-9)	0.0 (-9)
Total	88.4 (+17)	9.3 (+4)	2.3 (-21)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 1.9% EOC deferral, 0.4% maximum minus minimum deferral.

TABLE 4.42

WORK LOAD AND DEFERRAL SUMMARY--FF-1052 CLASS WITH NOTIONAL SMD, SIMULATION H

Department	Division	Work Load as % of Total Ship: Col. A*	EOC Deferral as % of Total Ship: Col. B*	Ratio, A:B
Operations	Control, communications & detection	15	0	--
	Hull, mechanical & electrical	35	2	1:0.1
Maintenance	Control, communications & detection	9	1	1:0.1
	Hull, mechanical & electrical	21	90	1:4.3
Support	All	20	7	1:0.4
Total ship, thou man-hours**	--	2,247 (-214)	[illegible] (-86)	--

* Rounded to nearest integer.

** Numbers in parentheses indicate the change from the baseline.

TABLE 4.43

EOC DEFERRAL AS PERCENT OF TOTAL EOC DEFERRAL, BY WORK CENTER AND WORK CATEGORY--FF-1052 CLASS, SIMULATION H

Work Center		Work Category	Percent of Total EOC Deferral
Division	Rating		
OM	FN	FM/OUS	2.1
MP	SN	FM	2.9
MT	SN	FM	0.3
MU	SN	FM	1.3
MQ	FN	FM	53.4
SI	SN	FM	5.7
MA	CD	PM/CM	0.4
MB	RE	PM/CM	0.6
MG	MB	PM/CM	18.8
ML	EN	PM/CM	2.8
MO	EI	PM/CM	10.5
SD	MS	OUS	1.2
SE	SH	OUS	0.1

assumptions regarding the composition of deferral, the various bounds relative to each work category for the 43,000 man-hours of shipwide EOC deferral are as follows:

- PM/CM deferral represents a maximum of 33.1%, or about 14,000 man-hours, of the total deferral
- FM deferral represents a maximum of 65.7%, or about 28,000 man-hours, of the total deferral
- OUS deferral represents a minimum of 1.3%, or about 600 man-hours, and a maximum of an estimated 95%, or 41,000 man-hours, of the total EOC deferral.

Simulation H Summary

4.56 The simultaneous application of a wide range of alternatives would result in a significant reduction in EOC deferral, elimination of problems caused by widely fluctuating deferrals over the course of the OPSKED, and the ability to set bounds relative to the amount of deferral expected to be represented by each work-load category.

V. FFG-7 CLASS RESULTS

5.1 This section describes the simulations conducted on the FFG-7 class (except for the baseline, which is described in Section II) and presents the results of each simulation. Simulations are described by the alternatives included in each. The methods and procedures used to develop the alternatives are detailed in Section III; however, the specific data used to define the alternatives in terms of FFG-7 class parameters are listed in this section. Simulation results are presented in the same manner and format used to describe the FF-1052 class results in Section IV.

5.2 Figure 5.1 shows the simulations conducted on the FFG-7 class. Simulation A (the baseline) was followed by three additional simulations (B, C, and D). The number of simulations and the alternatives to be incorporated into each simulation for this class were determined by the following considerations:

a. FFG-7 class simulations were to be conducted only if the results were expected to provide additional insight (beyond that obtainable through the FF-1052 class simulations) into the relative impacts of alternatives or if the alternatives themselves would be manifested differently on the FFG-7 class.

b. The total number of simulations conducted on both classes was necessarily limited to a reasonable

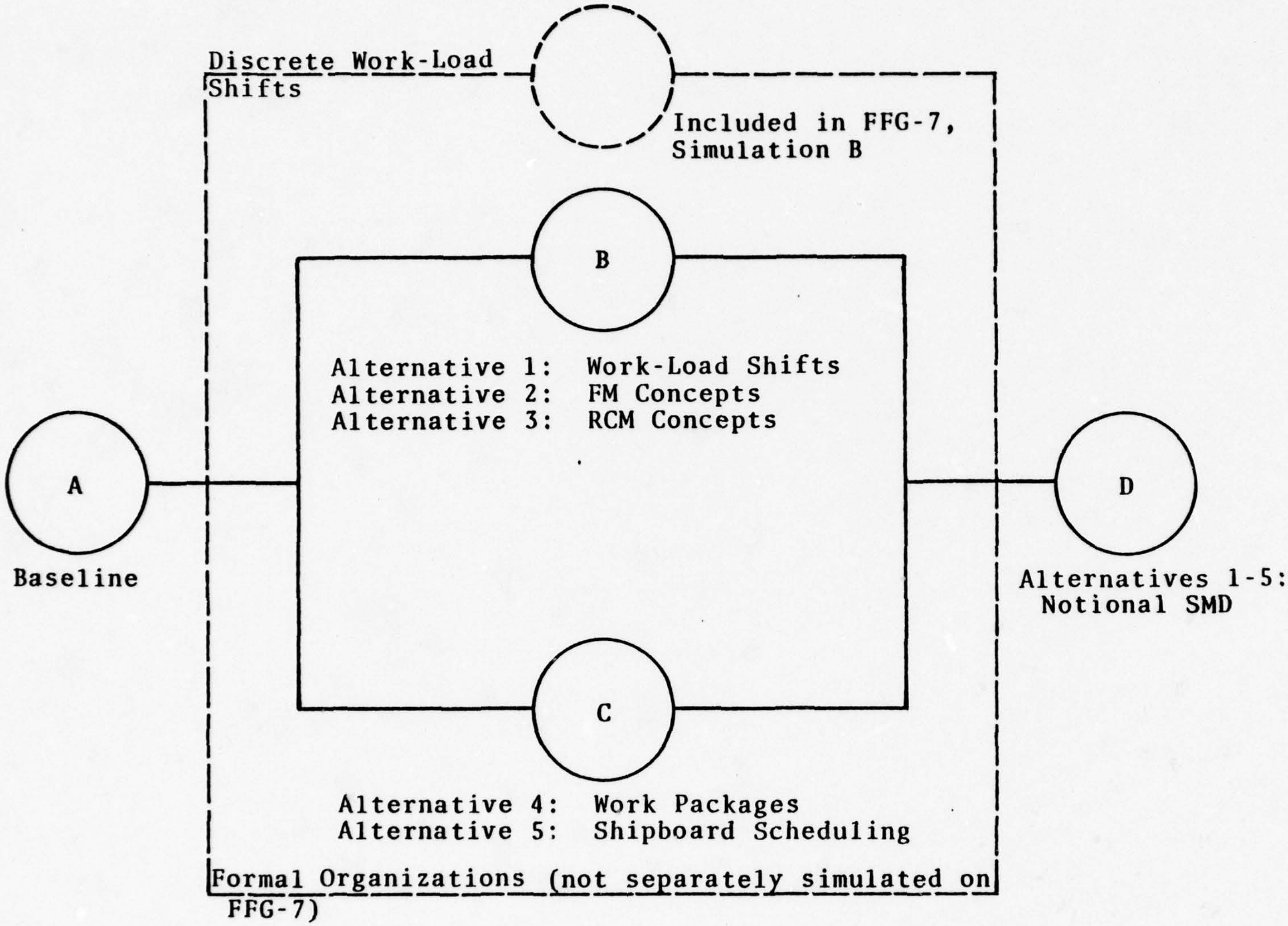

FIGURE 5.1

FFG-7 CLASS SIMULATIONS

number. To evaluate the combined impact of all possible combinations of alternatives (e.g., Alternative 1 with Alternative 4, Alternatives 4 and 5 with Alternative 3, etc.) several thousand simulations would be required.

SIMULATION B, FM-RCM CONCEPTS AND DISCRETE WORK-LOAD SHIFTS

5.3 FFG-7 Simulation B was conducted by applying Alternative 1, discrete work-load shifts; Alternative 2, new FM concepts; and Alternative 3, reliability-centered maintenance (RCM) concepts, to the FFG-7 baseline data and running the ship work load (SWL) algorithm against the resultant data base. Specifically, the following steps were followed in the order given:

a. Preventive maintenance (PM) work loads (hours per week) were reduced by 37.9% to reflect the RCM concepts

b. FM work loads (hours per week) were reduced by 30% and transferred to four FM teams (one per department) in accordance with the processes developed to reflect the new FM concepts. Table 5.1 shows the FM team work load (only FM was assigned to the FM teams)

c. FM team manning was constructed using the option whereby non-FM team work-center manning is reduced commensurate with the ability of each work center to suffer the reduction without creating additional deferral problems. The new manning breakdown, work center by work center, is given in Table 5.2

d. Non-FM team work centers were examined based on their original (baseline) deferral patterns

TABLE 5.1

FM TEAM WORK LOAD--FFG-7 CLASS, SIMULATION B*

Source Work Center/ FM Team		FM, hr/wk	
Division	Rating	Condition IV	Condition V
SC1	QM	33.05	13.97
SC1	SM	63.23	60.80
SC2	RM	31.23	21.92
SC3	BM	353.62	505.17
Total		481.13	601.86
FM1	SN	336.79	431.30
CS1	OS	50.42	19.17
CS1	EW	10.69	3.67
CS2	ST	37.74	24.51
CS2	TM	0.00	0.00
CS3	FT	35.56	7.61
CS3	GMM	0.00	0.00
CS3	GMG	26.69	34.66
CS4	ET	19.62	24.84
CS4	DS	0.00	0.00
CS4	IC	9.80	3.64
Total		190.52	118.10
FM2	SN	133.35	82.68
E1	EN	29.11	15.82
E1	EM	16.15	3.03
E2	MR	0.00	0.00
E2	EN	111.32	60.50
E2	EM	60.52	21.69
E2	HT	5.17	1.76
Total		222.27	102.80
FM3	FN	155.59	71.95
S1	MA	0.00	0.00
S1	YN	22.98	14.92
S1	PN	0.00	0.00
S1	SK	34.47	3.31
S1	DK	11.49	5.31
S1	HM	0.00	0.00
S2	MS	196.70	119.07
S2	SH	78.71	49.63
Total		334.35	192.24
FM4	SN	241.05	134.57

* FM team FM = 0.7 x total of source work center FM.

TABLE 5.2

MANNING COMPARISON--FFG-7 BASELINE TO SIMULATION B

Department	Work Center		Manning		
	Division	Rating	Baseline	Simulation B	Change
Ship Control	SC1	QM	7	6	-1
	SC1	SM	9	9	0
	SC2	RM	10	9	-1
	SC3	BM	14	10	-4
Combat Systems	CS1	OS	12	12	0
	CS1	EW	3	3	0
	CS2	ST	8	7	-1
	CS2	TM	1	1	0
	CS3	FT	10	7	-3
	CS3	GMM	2	2	0
	CS3	GMG	3	3	0
	CS4	ET	6	6	0
	CS4	DS	2	2	0
	CS4	IC	3	3	0
Engineering	E1	EN	6	6	0
	E1	EM	4	4	0
	E2	MR	1	1	0
	E2	EN	8	8	0
	E2	EM	7	5	-2
	E2	HT	4	3	-1
Support	S1	MA	1	1	0
	S1	YN	3	3	0
	S1	PN	1	1	0
	S1	SK	5	3	-2
	S1	DK	1	1	0
	S1	HM	1	1	0
	S2	MS	15	11	-4
	S2	SH	6	5	-1
FM teams	FM1	SN(SC)	--	9	+9
	FM2	SN(CS)	--	3	+3
	FM3	FN(ENG)	--	3	+3
	FM4	SN(SUP)	--	5	+5

and estimates of the patterns that would develop due to the work-load and manning modifications described in Steps a through c above. The objective was to identify discrete work-load transfers (other than the FM transfers) in accordance with the Alternative 1 procedures described in Section III. In the case of the FF-1052 class, the baseline results described a variety of possible deferral-eliminating work-load transfers. In the FFG-7 class case, however, the opportunity to reduce the expected deferral was limited by the lack of work centers that had excess capability. Table 5.3 displays the discrete work-load shifts finally identified as potentially beneficial. Note that the transfers involve only utility tasks (UTs) and that it was necessary to use the relatively undesirable procedure of limiting the transfers to either at-sea or in-port phases.

Sensitivity Parameters

5.4 Table 5.4 summarizes the sensitivity parameters used with this simulation. For this simulation, FM teams were treated as being composed of groups of individuals who would rotate back to their original work center periodically. Therefore, in addition to the 0.125-hr/wk/FM team member of specific FM-related training, FM work centers were assigned a pro-rata share of the training assigned to the various work centers from which the teams were constructed. Once the training was specified, the leave-during-LVUPK value associated with each FM team was computed. Table 5.5 shows the resultant training and leave (during LVUPK) for all work centers for this simulation.

TABLE 5.3

UT TRANSFERS--FFG-7, SIMULATION B

Work Center		UT Transferred, hr/wk	Phases
From	To		
SC1 QM	SC2 SM	3.97	At sea
SC3 BM	SC2 SM	35.90	In port
	SC3 RM	72.15	In port
CS1 OS	CS1 EW	11.19	At sea
CS2 TM	CS2 ST	9.58	In port
CS3 GMM	CS3 FT	4.50	In port
	CS3 GMG	3.33	At sea
CS3 GMG	CS3 FT	13.80	In port
CS4 ET	CS1 OS	32.65	In port
CS4 DS	CS1 OS	7.12	In port
CS4 IC	CS4 ET	6.93	At sea
	CS3 FT	12.81	In port
E2 EN	E1 EN	0.83	At sea

TABLE 5.4

SENSITIVITY PARAMETERS--FFG-7, SIMULATION B

Parameter	Value/Comments
Work centers	Baseline plus four FM teams
OPSKED	Same as baseline
Manning	Total same as baseline, work-center breakout shown in Table 5.2
Formal organization	Baseline plus one FM team per department
Work loads	Baseline modified as follows:
	PM = 0.621 x baseline PM
	FM = 0.7 x baseline FM, (FM assigned to FM teams)
	UT shifted as shown in Table 5.3
Work-load variances	Not used (same as baseline)
Work and productive allowances	Same as baseline
Workweek	Same as baseline
Detractors:	
Service diversions	Same as baseline
Training	Baseline modified as follows:
	FM team members assigned 0.125 hr/wk FM-specific training
	FM teams assigned pro-rata amount of associated work-center training
	Work-center training modified to reflect training transferred to FM teams
UA/TAD	Same as baseline
Leave	Non-FM team work centers: same as baseline
	FM teams: calculated in same manner as baseline

TABLE 5.5

FFG-7, TRAINING AND LEAVE (DURING LVUPK)--
SIMULATION B

Work Center		Leave, LVUPK, hr/billet/wk	On-Board Training		Off-Ship Training	
Division	Rating		Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
SC1	QM	15.57	3.71	2.45	40.46	803.33
SC1	SM	16.06	3.30	3.00	43.34	32.00
SC2	RM	16.21	3.48	0.71	21.55	356.14
SC3	BM	15.57	3.65	7.92	38.54	2,335.19
CS1	OS	13.29	8.20	1.54	22.67	3,102.67
CS1	EW	15.28	2.81	0.77	68.00	1,053.33
CS2	ST	15.11	4.98	2.07	37.33	546.29
CS2	TM	14.79	5.78	1.33	42.67	194.67
CS3	FT	15.27	4.72	0.58	44.95	300.19
CS3	GMM	15.72	3.27	4.67	78.89	119.99
CS3	GMG	15.72	4.82	2.64	17.07	629.33
CS4	ET	13.32	5.09	1.12	90.67	858.66
CS4	DS	14.30	3.70	6.03	192.13	297.33
CS4	IC	14.60	4.62	1.14	19.74	996.00
E1	EN	12.89	4.97	0.91	23.11	738.67
E1	EM	14.72	4.66	0.69	16.77	555.43
E2	MR	15.26	3.91	0.32	10.67	186.67
E2	EN	12.89	4.97	0.91	23.11	738.67
E2	EM	14.72	4.66	0.55	16.77	444.34
E2	HT	13.49	6.90	1.03	72.89	822.34
S1	MA	18.21	0.00	0.00	0.00	0.00
S1	YN	15.59	3.44	1.01	64.22	134.00
S1	PN	16.12	3.60	0.00	37.27	56.34
S1	SK	16.00	2.69	0.53	30.94	64.00
S1	DK	16.13	3.60	0.12	34.67	2.67
S1	HM	15.32	4.89	0.55	16.01	104.00
S2	MS	15.59	3.40	5.07	31.60	1,269.98
S2	SH	15.68	3.85	1.61	21.34	358.41
FM1	SM (SC)	14.43	3.70	6.56	35.04	1,895.70
FM2	SN (CS)	14.60	4.85	0.44	44.95	225.15
FM3	FN (ENG)	13.16	5.53	0.88	35.46	706.73
FM4	SN (SUP)	14.95	3.62	3.30	29.55	815.30

Simulation B Results

5.5 Table 5.6 displays the results, work center by work center, for the FFG-7 class with new FM and RCM concepts and discrete work-load transfers applied. Tables 5.7 through 5.10 summarize the information presented in Table 5.6 and include in parentheses the changes between Simulation B values and the baseline.

5.6 Analysis of Results. The overall effect of the three alternatives was to significantly increase the percentage of work centers having less than 3% EOC deferral and, shipwide, to lower the total expected EOC deferral to 8.4% from the baseline figure of 17.1%. Alternative 2, new FM concepts, and Alternative 3, RCM concepts, result in a reduced work load; however, the reduction in deferral caused by these alternatives does not occur efficiently. Shipwide, the FM reduction caused by Alternative 2 was approximately 335 hr/wk or, applying the productive allowance and summing over the operating cycle, roughly 95,000 man-hours. The PM reduction caused by Alternative 3 was about 309 hr/wk or, applying make-ready/put-away and productive allowances and summing over the operating cycle, about 112,000 man-hours. The two alternatives combined account for the 207,000-man-hour work-load reduction observed. Alternative 2, discrete workload shifts, accounted for approximately 30,000 man-hours of the 172,000-man-hour reduction in EOC deferral; therefore, the remaining 142,000-man-hour EOC deferral reduction is attributable to the new FM and RCM concepts. Comparing figures, the 207,000-man-hour work-load reduction from Alternatives 2 and 3 resulted in a 142,000-man-hour EOC deferral reduction, with the remainder of the work-load reduction basically translated into the increase in basal slack observed (from 9.2% shipwide in the baseline to 11.5% in this simulation) and the clustering of work centers into the >15% basal slack cell.

TABLE 5.6

FFG-7 CLASS STATUS WITH FM AND RCM CONCEPTS AND DISCRETE WORK-LOAD SHIFTS--SIMULATION B

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
SC1	QM	0.0	0.0	0.0	0.21	15.6	3.7	0.0
SC1	SM	0.0	0.0	0.0	-0.64	10.1	5.4	0.0
SC2	RM	0.0	0.5	0.1	5.51	4.7	6.8	0.1
SC3	BM	0.0	1.5	1.0	11.98	11.3	5.3	0.7
CS1	CS	3.5	5.0	5.0	10.85	0.0	8.2	4.9
CS1	EW	0.0	1.8	0.0	1.64	39.3	0.6	0.0
CS2	ST	0.0	1.1	0.4	5.27	0.4	5.2	0.3
CS2	TM	0.8	3.4	3.4	1.67	0.1	0.6	0.3
CS3	FT	0.0	1.0	0.0	3.80	14.6	2.2	0.0
CS3	GMM	1.0	4.1	3.9	4.57	0.3	1.4	0.7
CS3	GMG	0.0	1.8	1.2	4.04	21.1	1.5	0.2
CS4	ET	0.0	1.7	1.4	8.60	17.2	3.1	0.5
CS4	DS	0.0	2.1	1.7	4.08	20.5	0.9	0.2
CS4	IC	0.0	2.2	1.6	4.03	29.6	1.3	0.3
E1	EN	21.9	24.5	24.5	14.05	0.0	5.7	16.5
E1	EM	19.2	21.7	21.7	9.20	0.0	3.7	9.6
E1	MR	11.3	14.5	14.5	2.08	0.0	0.8	1.4
E2	EN	0.0	1.7	1.5	10.32	12.2	4.7	0.8
E2	EM	13.5	15.6	15.6	7.67	0.0	4.1	7.7
E2	HT	38.4	40.6	40.6	10.93	0.0	3.0	14.7
S1	MA	0.0	0.0	0.0	-0.09	42.8	0.4	0.0
S1	YN	0.0	1.3	0.8	3.45	15.3	1.7	0.2
S1	PN	0.6	2.0	1.9	0.85	0.0	0.7	0.2
S1	SK	0.0	0.6	0.2	2.00	2.8	2.1	0.1
S1	DK	0.0	0.0	0.0	-0.26	59.8	0.3	0.0
S1	HM	0.0	0.7	0.0	0.49	30.6	0.4	0.0
S2	MS	0.0	1.0	0.7	11.17	2.1	7.2	0.7
S2	SH	0.0	0.9	0.4	4.10	12.1	3.1	0.2
FM1	SN (SC)	23.7	27.3	27.3	25.92	0.0	7.6	24.8
FM2	SN (CS)	7.2	9.4	9.4	4.20	0.0	2.1	2.4
FM3	FN (ENG)	20.1	22.0	22.0	4.07	0.0	2.3	5.9
FM4	SN (SUP)	12.6	14.7	14.7	6.87	0.0	3.7	6.5
Total ship		7.0 1/	8.5 2/	8.4 1/	183.62 2/	11.5 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 5.7

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FFG-7 CLASS WITH FM AND RCM CONCEPTS AND DISCRETE WORK-LOAD SHIFTS, SIMULATION B

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	< 5	5-15	>15	Total
<3	6.3 (+3)	15.6 (+1)	40.6 (+23)	62.5 (+27)
3-10	12.5 (-6)	**	--	12.5 (-6)
>10	25.0 (-21)	--	--	25.0 (-21)
Total	43.8 (-24)	15.6 (+1)	40.6 (+23)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 8.4% EOC deferral, 11.5% basal slack.

TABLE 5.8

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FFG-7 CLASS WITH FM AND RCM CONCEPTS AND DISCRETE WORK-LOAD SHIFTS, SIMULATION B

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
< 1	25.0 (-4)	--	--	25.0 (-4)
1-5	37.5 (+30)	12.5 (-5)**	25.0 (-21)	75.0 (+4)
> 5	--	--	--	--
Total	62.5 (+26)	12.5 (-5)	25.0 (-21)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 8.4% EOC deferral, 1.5% maximum minus minimum deferral.

TABLE 5.9

WORK LOAD AND DEFERRAL SUMMARY--FFG-7 CLASS, WITH FM AND RCM CONCEPTS AND DISCRETE WORK-LOAD SHIFTS, SIMULATION B*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Ship Control	29 (0)	26 (-9)	1:0.9
Combat Systems	27 (0)	10 (-7)	1:0.4
Engineering	24 (-1)	56 (+13)	1:2.3
Support	20 (+1)	8 (+3)	1:0.4
Total ship, thou man-hours	1,400 (-207)	118 (-172)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

TABLE 5.10

APPROXIMATE EOC DEFERRAL--FFG-7 CLASS, SIMULATION B

Department	EOC Deferral, thou man-hours		
	Baseline	Simulation B	Change
Ship Control	101.5	30.7	-70.8
Combat Systems	49.3	11.8	-37.5
Engineering	124.7	66.0	-58.7
Support	14.5	9.5	-5.0
Total ship	290.0	118.0	-172.0

5.7 Table 5.6 indicates that the EOC deferral will be concentrated in the non-FM team engineering work centers (50.7% of total EOC deferral) and the FM team work centers (39.6% of total EOC deferral), with all remaining work centers accounting for only 9.7% of the total EOC deferral. This arises primarily from the manner in which the FM team work-center manning was constructed and the assumptions used in determining the training associated with each FM team. As with the analogous situation discussed in Section IV for the FF-1052 class, the use of another method to identify the work centers from which FM team manning will be taken and/or applying a different FM team training rationale would result in a significantly different dispersion of deferral throughout the ship.

Simulation B Summary

5.8 Table 5.11 shows the relative effects of Alternatives 1, 2, and 3 on both the FFG-7 and FF-1052 classes. From this table and the preceding tables associated with the alternatives, the following observations may be made:

a. Alternative 1, discrete work-load transfers, is relatively efficient in eliminating deferral. A high percentage of the work-load transfers is directly translated into a reduction in deferral. The improvement that can be obtained by the alternative, however, is limited by the initial amount and distribution of deferral, since the underlying assumption of the alternative is that undertasked work centers are present and, hence, transfer of work from overtasked work centers is possible.

TABLE 5.11

RELATIVE EFFECTS OF ALTERNATIVES 1, 2, AND 3

Alternative No.	Class	Baseline BOC Deferral, % of Total Work Load	Work-Load Transfers, thou man-hours	Work-Load Transfers, % of Total Work Load	Work-Load Reduction, thou man-hours	Work-Load Reduction, % of Total Work Load	Reduction in BOC Deferral, thou man-hours	Reduction in BOC Deferral, % of Baseline BOC Deferral	Reduction in BOC Deferral, % of Work-Load Transfer/Reduction
1	FF-1052	5.3	122	5	--	--	116	90	95
	FFG-7	18.1	36	2	--	--	30	10	83
2, 3	FF-1052	5.3	--	--	232	9	96	75	41
	FFG-7	18.1	--	--	207	13	142	49	69

b. Alternatives 2 and 3 result in a reduction in deferral. The reduction occurs inefficiently, since a significant portion of the actual work load reduction translates into an increase in basal slack rather than a decrease in deferral. This "loss" in efficiency is inversely proportional to the percentage of deferral initially present.

c. All three alternatives may improve the organic maintenance capability of the ship. The improvements due to Alternative 1 arise from the way that transfers are applied (i.e., selectively based on the deferral patterns of each work center). The improvements due to Alternatives 2 and 3 come from the actual maintenance work load reductions associated with the alternatives. The net impact of Alternative 2, new FM concepts, is highly sensitive to the method used to determine the modifications in work-center manning required to form FM teams as well as to the way training for FM team members is specified. For example, constructing FM teams using billets drawn from work centers normally accomplishing FM will be less effective than constructing FM teams based on the ability of all work centers on the ship to provide billets.

SIMULATION C, SHIPBOARD SCHEDULING AND IN-PORT MAINTENANCE PACKAGE

5.9 The FFG-7 Simulation C was conducted by applying Alternative 4, work packages, and Alternative 5, shipboard scheduling,

to the FFG-7 class baseline data and running the SWL algorithm against the resultant data base. The alternatives were evaluated together based on the rationale that the use of a notional work package would require that work centers review their work schedules to ensure that other work would not interfere with the accomplishment of work-package work during the IMAV and SRA phases.

Sensitivity Parameters

5.10 Sensitivity parameters were changed in a two-step process. First, the sensitivity parameters were modified to describe the notional work package. The FFG-7 notional work package shown in Table E.2 was applied directly; therefore, the baseline average weekly PM and CM work loads were modified to indicate that some PMS-associated work would be performed only during specified IMAV/SRA phases (and, hence, the average weekly PM and CM would be reduced), and work-load variances were constructed to account for the presence of the notional work-package work loads in the IMAV/SRA phases. Second, the work-load variances for all phases were modified to describe the effects of shipboard scheduling.

5.11 Using the procedures outlined in Section III, variances were computed with the objective of scheduling work load in a manner that would result in a relatively stable (i.e., unfluctuating) work-load-versus-capability imbalance for each work center throughout the OPSKED. Work centers fell into four general categories:

a. Work centers with slack in each phase, indicating that no shipboard scheduling has to be simulated to eliminate deferral--only one FFG-7 class work center, S1 MA, fell into the category.

b. Work centers with deferral during LVUPK phases only--six work centers, SC2 RM, CS1 EW, CS3 FT, S1 SK, S1 DK and S1 HM, fell into this category. For these work centers, work load was scheduled out of the LVUPK phases and into other in-port or at-sea phases. The scheduling associated with Work Center S1 DK was typical of that used for work centers in this category. For S1 DK, 2.02 hr/wk of FM were scheduled out of each LVUPK phase. The FM was rescheduled evenly into all at-sea phases, resulting in an increase of 0.21 hr/wk FM in the work center's average at-sea work load.

c. Work centers for which work load was scheduled out of at-sea phases, out of LVUPK phases and into non-LVUPK in-port phases--five work centers, SC1 QM, SC1 SM, CS1 OS, CS2 ST and SI PN, fell into this category. Work Center CS1 OS was typical of this group. Table 5.12 shows the scheduling applied to Work Center CS1 OS.

d. Work centers for which work load was scheduled out of in-port phases and into at-sea phases--16 work centers, SC3 BM, CS2 TM, CS3 GMM, CS3 GMG, CS4 ET, CS4 DS, CS4 IC, E1 EN, E1 EM, E2 MR, E2 EN, E2 EM, E2 HT, S1 YN, S2 MS, and S2 SH, fell into this category. The scheduling associated with Work Center E2 EN, typical of that applied to this category of work centers, is shown in Table 5.13.

Simulation C Results

5.12 Table 5.14 displays the results of FFG-7 class Simulation C, work center by work center. Tables 5.15 through 5.17 show

TABLE 5.12

CS1 OS SHIPBOARD SCHEDULING--SIMULATION C

Phase/Direction	Work Load Scheduled, hr/wk			
	PM	CM	FM	OUS
Out of LVUPK	8.37	0.00	10.00	28.33
Out of all at-sea phases	7.63	0.00	9.19	20.35
Into all in-port phases except LVUPK and SRAs	9.87	0.00	11.89	27.03

TABLE 5.13

E2 EN SHIPBOARD SCHEDULING--SIMULATION C

Phase/Direction	Work Load Scheduled, hr/wk			
	PM	CM	FM	OUS
Out of LVUPK	30.33	15.17	8.05	10.05
Out of in-port phases except LVUPK, IMAVs and SRAs	2.15	1.07	0.57	0.71
Out of IMAV 1, 2, 3, 5, 6 and each SRA	73.53	36.77	19.52	24.36
Out of IMAV 4	0.00	0.00	0.00	0.00
Into all at-sea phases	20.03	10.02	5.32	6.97

TABLE 5.14

FFG-7 CLASS STATUS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING--SIMULATION C

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
SC1	QM	0.0	0.0	0.0	-0.00	13.8	3.7	0.0
SC1	SM	0.0	0.0	0.0	-0.00	9.5	5.5	0.0
SC2	RM	0.0	0.0	0.0	0.11	9.1	5.9	0.0
SC3	BM	44.4	45.9	45.9	30.39	0.0	13.6	33.6
CS1	OS	11.0	11.3	11.2	5.56	0.0	7.6	4.6
CS1	EW	0.0	0.4	0.0	0.40	38.0	0.6	0.0
CS2	ST	4.5	4.6	4.6	1.16	0.0	5.3	1.3
CS2	TM	29.4	30.6	30.6	1.12	0.0	0.8	1.3
CS3	FT	0.0	0.0	0.0	0.00	10.4	2.3	0.0
CS3	GMM	28.4	29.4	29.4	2.38	0.0	1.6	2.6
CS3	GMG	26.6	27.4	27.4	2.81	0.0	2.2	3.3
CS4	ET	12.1	12.5	12.5	2.39	0.0	3.7	2.5
CS4	DS	2.5	3.7	3.7	1.29	0.0	1.0	0.2
CS4	IC	9.5	15.5	15.3	5.08	0.0	1.8	1.5
E1	EN	34.3	35.2	35.2	7.93	0.0	5.7	10.8
E1	EM	27.2	28.6	28.6	7.11	0.0	3.5	5.4
E2	MR	28.6	34.2	34.1	2.29	0.0	0.9	1.6
E2	EN	32.5	33.6	33.4	9.06	0.0	6.9	12.3
E2	EM	17.4	21.1	20.5	10.33	0.0	5.2	5.7
E2	HT	38.1	39.1	39.1	6.87	0.0	3.3	6.9
S1	MA	0.0	0.0	0.0	-0.09	42.8	0.4	0.0
S1	YN	5.6	5.8	5.8	0.55	0.0	1.9	0.6
S1	PN	1.7	1.8	1.8	0.05	0.0	0.6	0.1
S1	SK	0.0	0.0	0.0	0.00	19.6	2.2	0.0
S1	DK	0.0	0.0	0.0	0.00	35.9	0.4	0.0
S1	HM	0.0	0.0	0.0	0.00	28.7	0.4	0.0
S2	MS	8.8	8.9	8.9	2.56	0.0	9.4	4.5
S2	SH	5.8	6.0	6.0	0.98	0.0	3.8	1.2
Total ship		17.8 1/	18.7 1/	18.6 1/	100.42 2/	9.2 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by work-center capabilities in hours.

TABLE 5.15

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FFG-7 CLASS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING, SIMULATION C

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	3.6 (0)	14.3 (0)	17.8 (0)	35.7 (0)
3-10	17.9 (0)	--	--	17.9 (0)
>10	46.4 (0)	**	--	46.4 (0)
Total	67.9 (0)	14.3 (0)	17.8 (0)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 18.6% EOC deferral, 9.2% basal slack.

TABLE 5.16

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FFG-7 CLASS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING, SIMULATION C

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	35.7 (+7)	14.3 (+14)	14.3 (+14)**	64.3 (+35)
1-5	0 (-7)	3.6 (-14)	28.5 (-18)	32.1 (-39)
>5	--	--	3.6 (+4)	3.6 (+4)
Total	35.7 (0)	17.9 (0)	46.4 (0)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 18.6% EOC deferral, 0.9% maximum minus minimum deferral.

TABLE 5.17

WORK LOAD AND DEFERRAL SUMMARY--FFG-7 CLASS WITH NOTIONAL WORK PACKAGE AND SHIPBOARD SCHEDULING, SIMULATION C*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Ship Control	29 (0)	34 (-1)	1:1.2
Combat Systems	27 (0)	17 (0)	1:0.6
Engineering	25 (0)	43 (0)	1:1.7
Support	19 (0)	6 (+1)	1:0.3
Total ship, thou man-hours	1,619 (+12)	301 (+11)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

summary information for the simulation and include the changes occurring between this simulation and the class baseline.

5.13 Analysis of Results. The total ship EOC deferral for Simulation C is 18.6%, up slightly from the 18.1% present in the baseline. Basal slack remained unchanged at 9.2%. The increase in deferral arises from the additional 12,000 man-hours of work load required of the ship due to the notional work package. Most of the additional work load was concentrated in the Engineering Department, and, accordingly, most of the additional EOC deferral also appeared in this department, particularly in the EN and EM work centers. Work Centers CS4 IC and S2 MS account for the remainder of the increase in deferral.

5.14 The effects of shipboard scheduling are reflected in the changes in the ship's total maximum minus minimum deferral (0.9% for Simulation C, 2.0% for the baseline), maximum number of billets needed to eliminate deferral (100.42 in Simulation C, 238.00 in the baseline) and significant change in the percentage of work centers with less than 1% maximum minus minimum deferral (as shown in Table 5.16).

Simulation C Summary

5.15 The application of the notional work package to the FFG-7 class had the same effect as observed when a notional work package was applied to the FF-1052 class (i.e., a slight increase in EOC deferral). For the FF-1052 class, part of this increase was offset by shipboard scheduling. For the FFG-7 class, shipboard scheduling had a lesser effect, primarily because a larger percentage of work centers had deferral in all or most phases in the baseline conditions. The opportunity to reduce deferral by scheduling work into phases with excess

capability was therefore restricted. For both classes, however, scheduling "smoothed" the deferral problem since large spikes in deferral did not occur during the OPSKED. This effect is desirable because it may facilitate the application of other alternatives. In addition, the elimination of periods during which abnormally high amounts of deferral are likely to accumulate ensures that, should it be necessary to shift to a wartime posture at any given moment, an average, rather than a worst case, deferral problem would exist.

SIMULATION D, NOTIONAL SMD

5.16 The FFG-7 class Simulation D was conducted by applying Alternatives 1 through 5 and a portion of Alternative 7 to the FFG-7 class baseline data and running the SWL algorithm against the resultant data base. The modified data base also served as the foundation for the notional ship manpower document (SMD) for the FFG-7 class. Since the FFG-7 class notional SMD (delivered under separate cover) contains a detailed description of the work loads, organization, manning levels and other parameters as they appeared in the modified data base used for Simulation D, the discussions in this report will be limited to the way the notional SMD/Simulation D data were developed. Redundant displays of the actual work loads, manning, etc., will not be provided.

Sensitivity Parameters

5.17 Sensitivity parameters were changed through a series of steps equating to the application of each alternative to be included in the simulation. The steps were as follows:

a. A portion of Alternative 7, a functionally based formal organization, was applied. Specifically, ratings QM, SM and BM were merged into a single notional rating, CD, and ratings EM and IC were merged into the notional rating EI. The rating merger was simulated by summing the work loads, manning and training requirements for the work centers involved.

b. Alternative 4, work packages, was applied. The notional FFG-7 class work package described in Appendix E was used; however, the IMAV/SRA work loads and average hours-per-week PM and CM reductions were reaggregated to reflect the rating mergers discussed in (a) above.

c. Alternative 3, reliability-centered maintenance principles, was applied by reducing the PM work load for each work center (now including the notional work package) by 37.9%.

d. Alternative 4, new FM concepts, was applied by transferring all FM to four FM teams and reducing the FM work load by 30%.

e. Based on estimates of the deferral patterns that would exist with the above listed alternatives applied, work-load transfers were identified and appropriate changes made to work-center work loads. The majority of the shifts consisted of either the shifting of non-rate/rating-sensitive Condition V OPMAN requirements to work centers having sufficient E-3-and-below manning to perform the watches, shifting rate-sensitive Condition V OPMAN requirements to work centers

having sufficient E-4-and-above manning to perform the watches, or shifting limited amounts of non-rating-sensitive OUS among work centers.

f. Based on estimates of the deferral patterns that would occur as a result of Steps a through e above, Alternative 5, shipboard scheduling, was applied using the process discussed in Section III.

5.18 The work-center manning levels used with Simulation D and the FFG-7 notional SMD are shown in Table 5.18. The training and leave (during LVUPK) values are shown in Table 5.19.

Simulation D Results

5.19 Table 5.20 displays the results, work center by work center, for the FFG-7 class with the notional SMD data applied. Tables 5.21 through 5.23 summarize information from Table 5.20 and show the changes that occurred relative to the baseline values.

5.20 Analysis of Results. Shipwide, the expected EOC deferral has been reduced from the baseline value of 18.1% to 4.8%, maximum deferral reduced from 18.1% to 4.9% and minimum deferral reduced from 16.1% to 3.6%. The maximum number of billets needed to eliminate deferral has been lowered to 93.05 from the baseline level of 238.00, and shipwide maximum minus minimum deferral has dropped from the baseline value of 2.0% to 1.3%. Basal slack has also been lowered to 8.3% from the baseline level of 9.2%. Nearly 70% of the work centers now have less than 3% EOC deferral and over 96% have less than 5% maximum minus minimum deferral.

TABLE 5.18

FFG-7 CLASS WORK-CENTER MANNING--
NOTIONAL SMD

Department	Work Center	Manning
Ship control	AA CD	13
	AB RM	9
	AC SN*	17
	AD SN*	2
Combat systems	BA OS	12
	BB EW	3
	BC ST	7
	BD TM	1
	BE FT	10
	BF GMM	2
	BG GMG	3
	BH ET	6
	BI DS	2
Engineering	DA EN	6
	DB EI	4
	DC EI	7
	DD MR	1
	DE EN	7
	DF HT	4
	DG FN*	5
Support	SA HM	1
	SB SK	4
	SC DK	1
	SD MS	11
	SE SH	4
	SF MA	1
	SG YN	3
	SH PN	1
	SI SN*	6
Total	--	153

* FM team.

TABLE 5.19

FFG-7 TRAINING AND LEAVE (DURING LVUPK)--
NOTIONAL SMD, SIMULATION D

Work Center		Leave, LVUPK,	On-Board Training		Off-Ship Training	
Division	Rating	hr/billet/wk	Variable, hr/billet/wk	Fixed, hr/wk	Variable, hr/billet/yr	Fixed, hr/yr
AA	CD	15.68	3.59	8.34	40.24	2,229.52
AB	RM	16.21	3.48	0.72	21.55	360.59
AC	SN	15.73	3.61	10.01	39.40	2,485.76
AD	SN	15.73	3.61	1.18	39.40	292.44
BA	OS	13.29	8.20	1.54	22.67	3,102.67
BB	EW	15.28	2.81	0.77	68.00	1,053.33
BC	ST	15.11	4.98	2.12	37.33	557.67
BD	TM	14.79	5.78	1.33	42.67	194.67
BE	FT	15.27	4.72	1.02	44.95	525.34
BF	GMM	15.72	3.27	4.67	78.89	119.99
BG	GMG	15.72	4.82	2.64	17.07	629.33
BH	ET	13.32	5.09	1.12	90.67	858.66
BI	DS	14.30	3.70	6.03	192.13	297.33
DA	EN	12.89	4.97	0.91	23.11	738.67
DD	EI	14.72	4.66	0.69	16.77	555.43
DC	EI	14.67	4.64	1.67	18.04	1,419.18
DD	MR	15.26	3.91	0.32	10.67	186.67
DE	EN	12.89	4.97	0.80	23.11	646.34
DF	HT	13.49	6.90	1.54	72.89	1,232.75
DG	FN	14.61	4.33	0.61	20.87	422.52
SA	HM	15.32	4.89	0.55	16.01	104.00
SB	SK	16.00	2.69	0.42	30.94	51.20
SC	DK	16.13	3.60	0.12	34.67	2.67
SD	MS	15.59	3.40	5.84	31.60	1,463.50
SE	SH	15.68	3.85	1.34	21.34	298.67
SF	MA	18.21	0.00	0.00	0.00	0.00
SG	YN	15.59	3.44	1.01	64.22	134.00
SH	PN	16.12	3.60	0.00	37.27	56.34
SI	SN	15.62	3.55	2.79	28.18	681.52

TABLE 5.20

FFG-7 CLASS STATUS--NOTIONAL SMD, SIMULATION D

Work Center		Deferral, % of Total Work Load			Maximum Billets to Eliminate Deferral	Basal Slack, % of Capability	Work Load, % of Total Ship	EOC Deferral, % of Total Ship
Division	Rating	Min.	Max.	EOC				
AA	CD	0.0	0.3	0.2	4.55	1.8	8.7	0.5
AB	RM	0.0	0.0	0.0	0.01	5.1	6.8	0.0
AC	SN	10.2	12.5	12.5	26.64	0.0	13.2	34.2
AD	SN	0.0	2.4	1.4	1.69	11.3	1.2	0.3
BA	OS	0.0	0.3	0.0	3.94	0.6	7.7	0.0
BB	EW	0.0	1.5	0.3	1.58	38.6	0.7	0.0
BC	ST	0.0	0.0	0.0	0.59	1.7	5.1	0.0
BD	TM	0.0	2.5	2.4	1.00	0.1	0.6	0.3
BE	FT	0.0	0.0	0.0	-0.09	10.2	5.1	0.0
BF	GMM	0.2	4.0	4.0	1.92	0.1	1.4	1.2
BG	GMG	0.0	0.9	0.6	2.29	15.0	1.6	0.2
BH	ET	0.0	0.7	0.6	3.94	10.7	3.3	0.4
BI	DS	0.1	1.9	1.7	2.93	0.3	1.1	0.4
DA	EN	15.4	19.5	19.5	8.32	0.0	5.4	21.7
DB	EI	17.3	19.6	19.6	7.93	0.0	3.7	15.1
DC	EI	0.4	5.3	4.8	7.43	0.5	4.6	4.6
DD	MR	0.3	9.4	8.4	1.60	0.6	0.7	1.3
DE	EN	0.1	4.0	3.6	6.63	0.3	4.9	3.7
DF	HT	18.1	19.9	19.9	4.42	0.0	2.7	11.1
DG	GN	0.0	0.0	0.0	-0.02	0.8	3.5	0.0
SA	HM	0.0	0.0	0.0	0.00	30.6	0.4	0.0
SB	SK	0.0	0.2	0.1	0.60	17.3	2.5	0.1
SC	DK	0.0	0.0	0.0	-0.26	59.5	0.3	0.0
SD	MS	0.0	0.1	0.0	1.39	5.1	6.8	0.0
SE	SH	0.6	0.8	0.8	0.42	0.0	2.7	0.5
SF	MA	0.0	0.0	0.0	-0.09	42.8	0.4	0.0
SG	YN	0.0	0.1	0.0	0.44	14.7	1.7	0.0
SH	PN	2.1	2.1	2.1	0.05	0.0	0.7	0.3
SI	SN	3.7	4.4	4.4	2.74	0.0	4.3	4.0
Total ship		3.6 1/	4.9 1/	4.8 1/	93.05 2/	8.3 3/	100.0	100.0

1/ Sum of work-center deferrals in hours divided by sum of work-center work loads in hours.

2/ Sum of positive maximum billets to eliminate deferral.

3/ Sum of work-center basal slacks in hours divided by sum of work-center capabilities in hours.

TABLE 5.21

PERCENTAGE OF WORK CENTERS BY BASAL SLACK AND EOC DEFERRAL CELL--FFG-7 CLASS WITH NOTIONAL SMD, SIMULATION D

EOC Deferral, %	Percentage of Work Centers*			
	Basal Slack, %			
	<5	5-15	>15	Total
<3	24.1 (+21)	27.6 (+13)	17.3 (-1)	69.0 (+33)
3-10	17.2 (-1)	**	--	17.2 (-1)
>10	13.8 (-32)	--	--	13.8 (-32)
Total	55.1 (-12)	27.6 (+13)	17.3 (-1)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 4.8% EOC deferral, 8.3% basal slack.

TABLE 5.22

PERCENTAGE OF WORK CENTERS BY EOC DEFERRAL AND MAXIMUM MINUS MINIMUM DEFERRAL CELL--FFG-7 CLASS WITH NOTIONAL SMD, SIMULATION D

Maximum Minus Minimum Deferral, %	Percentage of Work Centers*			
	EOC Deferral, %			
	<3	3-10	>10	Total
<1	55.2 (+27)	3.4 (+3)	--	58.6 (+30)
1-5	13.8 (+7)	10.4 (-8)**	13.8 (-32)	38.0 (-30)
>5	--	3.4 (+3)	--	3.4 (+3)
Total	69.0 (+34)	17.2 (-2)	13.8 (+32)	100.0 (0)

* Numbers in parentheses indicate the change from the baseline.

** Ship: 4.8% EOC deferral, 1.3% maximum minus minimum deferral.

TABLE 5.23

WORK LOAD AND DEFERRAL SUMMARY--FFG-7 CLASS
WITH NOTIONAL SMD, SIMULATION D*

Department	Work Load as % of Total Ship: Col. A**	EOC Deferral as % of Total Ship: Col. B**	Ratio, A:B
Ship Control	30 (+1)	35 (0)	1:1.2
Combat System	25 (-2)	3 (-14)	1:0.1
Engineering	26 (+1)	57 (+14)	1:2.2
Support	19 (0)	5 (0)	1:0.3
Total ship, thou man-hours	1,400 (-207)	78 (-222)	--

* Numbers in parentheses indicate the change from the baseline.

** Rounded to nearest integer.

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EVALUATION OF ALTERNATIVE SHIP ORGANIZATIONS.(U)

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1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6

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5.21 The positive benefit of using alternatives together is apparent in that the total reduction in deferral for the simulation is significantly higher than any that was achieved through the application of a single alternative. For example, the reduction in work load caused by the new FM and RCM concepts reduces the deferral to the point where shipboard scheduling and discrete work-load transfers are more effective, since, for some work centers, the work-load reduction in certain phases will allow other work to be accomplished.

VI. ANALYSIS OF MAINTENANCE WORK-LOAD TRANSFER OFF SHIP

6.1 This section explores the feasibility and impact of transferring residual deferred maintenance to the intermediate maintenance activity (IMA) or depot level. The residual maintenance problems addressed are those potentially arising from the deferral projected to exist on the FF-1052 and FFG-7 classes <u>after</u> the implementation of alternatives designed to improve the organic maintenance capability of the ships. The decision to address the problems remaining after the implementation of alternatives was based on the rationale that the transfer of maintenance tasks to an IMA or depot should be considered subsequent to a concerted effort to improve (and utilize) the organization-level maintenance capability to the fullest extent.

GENERAL APPROACH

6.2 The general approach involved the following sequential steps:

- Identify, for each class, the total work deferral expected to remain after organization-level alternatives are applied
- Break down this total residual deferral among the component work categories (OPMAN, PM, CM, FM, UT, and A/S)

- Determine which portion of the component deferral could feasibly and profitably be transferred to an IMA or depot
- Evaluate the impact on the residual maintenance problem of the transfer of maintenance work load to an off-ship activity.

IDENTIFICATION OF RESIDUAL MAINTENANCE PROBLEMS

6.3 The total deferral projected to accumulate on each class with organization-level alternatives implemented was determined in Sections IV and V. In Simulation H for the FF-1052 class and Simulation D for the FFG-7 class, the SWL algorithm was applied to data bases that reflected the notional implementation of all the applicable organization-level alternatives described in Section III. Accordingly, the results of these comprehensive simulations were used as the basis for the ensuing analysis.

Categorization of Deferral

6.4 Earlier in the overall study effort, categorization of deferral into the various pertinent work categories was generally limited to a qualitative effort (i.e., the categories of work likely to be deferred, where possible, were deduced based on the general nature and type of work load assigned to various work centers, divisions and/or departments). Since the objectives to be met during this portion of the study required a quantitative evaluation, a methodology was developed for use in disaggregating deferral into its component work categories. The full methodology is described in Appendix F.

6.5 The deferral categorization methodology was applied to each work center exhibiting end of cycle (EOC) deferral in the SWL algorithm outputs for the selected simulations. Tables 6.1 and 6.2 show the resultant breakdown of the deferral into each work category for each affected work center on the FF-1052 and FFG-7 classes. For reference, the percentage of the total PM and CM assigned to each work center that is expected to be deferred is also shown in the tables, as is the time (hours per man per week) that would be required (beyond the Navy standard workweek) for each work center to accomplish all the deferral itself. These hours include the make-ready/put-away and productive allowances applicable to the various categories of work.

Identification of Problem Deferral

6.6 Since transfer of work to an IMA or depot will, in itself, impose a certain work-load requirement on a work center, a point exists at which it is more realistic to require the work center to accomplish the work, even though a slight increase in work-week hours beyond the Navy standard workweek will be necessary. For example, in Table 6.1, the PM and CM deferral for Work Center MA CD represents 0.7% and 0.5% of the total PM and CM work loads, respectively. For this work center, only 0.21 hr/man/wk are required to accomplish all the expected deferral (PM, CM, UT and A/S). The advisability of transferring PM and/or CM from this work center to an IMA or depot, therefore, may be questioned because the amount of work-center effort required to accomplish the transfer may exceed the reduction in work load caused by the transfer.

6.7 Deferral was treated as a "problem" (i.e., requiring IMA or depot-level assistance) only if one or both of the following conditions existed.

TABLE 6.1
FF-1052 CLASS RESIDUAL DEFERRAL

Work Center		Residual Deferral, hr/wk								
		Category						% of PM Deferred	% of CM Deferred	Hr/Man/Wk to Eliminate all Deferral
Division	Rate/ Rating	OPMAN	PM	CM	FM	UT	A/S			
MA	CD	0.00	0.28	0.11	0.00	0.04	0.18	0.7	0.5	0.21
MB	RE	0.00	0.27	0.41	0.00	0.05	0.06	1.9	1.4	0.52
MK	MB*	0.00	13.30	7.79	0.00	0.97	2.78	7.2	5.3	2.31
ML	EN*	0.00	0.92	0.82	0.00	0.16	2.05	8.8	6.5	2.54
MO	EI*	0.00	5.71	4.63	0.00	1.02	3.06	13.3	9.7	3.87
MP	SN	0.00	0.71	0.00	2.99	0.23	0.38	2.0	--	0.60
MQ	FN*	0.00	3.37	0.00	76.80	0.55	0.25	30.8	--	14.05
MT	SN	0.00	0.08	0.00	0.32	0.02	0.04	2.0	--	0.58
MU	SN	0.00	0.30	0.00	1.28	0.10	0.16	1.9	--	0.58
OM	FN**	1.39	0.00	0.00	0.00	0.65	1.34	--	--	0.31
SD	MS	0.00	0.00	0.00	0.00	0.05	1.72	--	--	0.42
SB	SH	0.00	0.00	0.00	0.00	0.06	0.08	--	--	0.04
SF	PY	0.00	0.00	0.00	0.00	0.00	0.05	--	--	0.02
SI	SN*	0.00	0.[illegible]	0.00	5.47	0.26	1.97	3.6	--	1.28
Total		1.39	25.80	13.76	86.86	4.16	14.12	--	--	--

* Problem work center.

** Although OPMAN (watchstanding) is shown as deferral, in reality, the work center would undoubtedly stand all watches, even though 0.12 hr/man/wk beyond the Navy standard workweek would be required to do so.

TABLE 6.2

FFG-7 CLASS RESIDUAL DEFERRAL

Work Center		Residual Deferral, hr/wk								
		Category						% of PM Deferred	% of CM Deferred	Hr/Man/Wk to Eliminate all Deferral
Division	Rate/ Rating	OPMAN	PM	CM	FM	UT	A/S			
AA	CD	0.00	0.27	0.18	0.00	0.16	0.41	0.7	0.5	0.10
AC	SN*	0.00	0.00	0.00	80.83	0.00	1.72	--	--	5.83
AD	SN	0.00	0.00	0.00	0.57	0.00	0.28	--	--	0.51
BA	OS	0.00	0.01	0.00	0.00	0.00	0.06	0.1	--	0.01
BB	EW	0.00	0.04	0.05	0.00	0.07	0.00	0.7	0.6	0.07
BD	TM*	0.00	0.37	0.22	0.00	0.06	0.00	4.2	3.0	0.91
BF	GM*	0.00	1.36	0.83	0.00	0.02	0.18	5.4	3.9	1.67
BG	GG	0.00	0.26	0.15	0.00	0.05	0.07	1.2	0.8	0.24
BH	ET	0.00	0.23	0.50	0.00	0.05	0.21	0.9	0.7	0.23
BI	DS	0.00	0.37	0.43	0.00	0.10	0.00	2.9	2.2	0.61
DA	EN*	0.00	11.82	7.55	0.00	3.04	26.46	58.9	42.6	10.48
DB	EM*	0.00	11.08	9.02	0.00	7.00	3.61	100.0	100.0	10.21
DC	EI*	0.00	5.11	3.39	0.00	0.58	0.39	7.8	19.1	1.89
DD	MR*	0.00	1.43	1.02	0.00	0.10	0.08	14.0	10.1	3.67
DE	EN*	0.00	4.34	2.72	0.00	0.34	0.16	5.5	4.0	1.52
DF	HT*	0.00	13.00	7.77	0.00	1.27	0.95	32.0	23.3	8.07
SB	SK	0.00	0.00	0.00	0.00	0.00	0.12	--	--	0.04
SE	SH	0.00	0.01	0.01	0.00	0.01	1.12	0.9	1.1	0.36
SH	PN	0.00	0.00	0.00	0.00	0.01	0.75	--	--	0.91
SI	SN*	0.00	0.00	0.00	9.09	0.00	0.54	--	--	1.93
Total		0.00	49.70	33.84	90.49	12.80	37.11	--	--	--

* Problem work center.

- More than 3% of the total PM or more than 3% of the total CM was expected to be deferred
- The total time required for the work center to eliminate all deferral exceeded 1 hr/man/wk.

Work centers demonstrating one or both of these conditions are noted as "problem" work centers on Tables 6.1 and 6.2.

IMPACT OF WORK TRANSFER

6.8 The application of the criteria described above narrowed the analysis population to 5 work centers for the FF-1052 class and 10 work centers for the FFG-7 class. As can be seen from the following table, these work centers accounted for the majority of the total PM and CM expected to be deferred by each class:

Class	Percent of Total Category Deferral	
	PM	CM
FF-1052 (5 problem work centers)	94	96
FFG-7 (10 problem work centers)	98	96

Impact on IMA or Depot

6.9 The impact of transferring work to the IMA or depot level was viewed from two perspectives: that of the receiving activity and that of the ship. To determine the impact on the receiving activity, the assumption was made that all residual deferred PM and CM for the problem work centers was transferable and would in fact be transferred.

6.10 Table 6.3 shows the hours of work that would be transferred to an IMA or depot from a single ship of each class. The totals

TABLE 6.3

IMA/DEPOT HOURS PER WEEK REQUIRED TO ACCOMPLISH TRANSFERRED WORK

Transferred From		IMA/Depot, hr/wk	
		Category	
Ship	Work Center	PM	CM
FF-1052	MK MB	13.30	7.79
	ML EN	0.92	0.82
	MO EI	5.71	4.63
	MQ FN	3.37	0.00
	SI SN	0.86	0.00
FFG-7	AC SN	0.00	0.00
	BD TM	0.37	0.22
	DF GM	1.36	0.83
	DA EN	11.82	7.55
	DB EM	11.08	9.02
	DC EI	5.11	3.39
	DD MR	1.43	1.02
	DE EN	4.34	2.72
	DF HT	13.00	7.77
	SI SN	0.00	0.00

may be interesting, but an analysis of the type of work to be transferred and the associated skills required to accomplish the work are more valuable.

6.11 The precise skills required to perform the transferred work can only be determined by specifying exact tasks to be transferred (in the case of PM) or estimating the probable task that would be reflected in the CM. Such a degree of detail is beyond the scope of this overall analysis. However, since the general responsibilities of each work center involved and the composition of the work center are known, the following general assessments are made:

a. The overwhelming majority of the work that potentially would be transferred to an IMA or depot would fall into the hull, mechanical and electrical skill areas. Specifically, Work Center MK MB on the FF-1052 is composed of individuals with MM and BT skills performing main-propulsion-associated work. Similarly, Work Centers DA EN and DB EM on the FFG-7 consist of ENs and EMs who maintain the gas turbines for the ship. Work Centers ML EN on the FF-1052 and DE EN on the FFG-7 consist of ENs performing maintenance on auxiliary machinery. Work Centers MO EI on the FF-1052 and DC EI on the FFG-7 consist of EM- and IC-trained individuals working on main and auxiliary electrical components and equipment. Work Centers DO MR and DR HT on the FFG-7 consist of MRs and HTs performing rating-associated maintenance work in the machinery repair and fabrication areas. The work transferred to the IMA or depot level would naturally be

of the same type and require the same skills as those associated with the source work centers.

b. A limited amount of work requiring skills associated with the ordnance system occupational field would potentially be transferred from the FFG-7, since Work Center BD TM is composed of TMs and Work Center DF GMM is composed of GMMs.

c. A limited amount of work requiring only basic fireman and seaman skills potentially would be transferred from Work Centers MQ FN and SI SN on the FF-1052.

Impact on Ship

6.12 The transfer of work to the IMA and/or depot level as described above will result in less than 3% of the PM and less than 3% of the CM for any work center potentially remaining unaccomplished. The most significant amount of maintenance deferral not yet addressed then would be that concentrated in the facilities maintenance area. With organization-level alternatives applied, FM was assigned to several teams. For most of these teams, the work load assigned exceeded their capability. The teams, their total FM work load and the percentage of unaccomplished FM are shown in Table 6.4.

6.13 In the case of the FF-1052, most of the unaccomplished FM will be concentrated in the engineering spaces (the responsibility of Work Center MQ FN), while for the FFG-7, the unaccomplished FM will be centered in spaces under the responsibility of the ship Control/Communications and Combat Systems departments. Several alternatives would be available to minimize the impact of deferring/not accomplishing FM. First, FM

TABLE 6.4

FM TEAM WORK LOAD AND DEFERRAL

Class	Work Center	Total FM, hr/wk	FM Deferral, hr/wk	Percent Deferral
FF-1052	MP SN	168.58	2.99	1.8
	MQ FN	273.92	76.80	28.0
	MT SN	18.73	0.32	1.7
	MU SN	74.87	1.28	1.7
	SI SN	165.43	5.47	3.3
	OL SN	191.59	0.00	0.0
Total	--	893.11	86.86	9.7
FFG-7.	AC SN	444.73	80.83	18.2
	AD SN	37.62	0.57	1.5
	DG FN	116.98	0.00	0.0
	SI SN	187.81	9.09	4.8
Total	--	787.14	90.49	11.5

team manning may be adjusted by shifting billets from one team to another. The total deferred FM will remain relatively constant under such shifts, but the deferral may be spread more evenly among all spaces in the ship. Second, the frequency of accomplishment of certain low-priority FM tasks may be modified to ease the burden on the FM teams. Third, selected FM tasks may be transferred back to non-FM team work centers for accomplishment. The net result of these actions would be to significantly lower the amount of unaccomplished FM.

SUMMARY

6.14 Transfer of selected maintenance tasks to the IMA or depot level will eliminate most residual PM/CM deferral problems that exist under the situation prescribed by the application of organization-level alternatives. The receiving activities will be required to assist primarily in the hull, mechanical and electrical areas. Residual FM problems will exist; however, alternatives will be available to reduce the impact of these problems.

VII. CONCLUSIONS AND RECOMMENDATIONS

7.1 This section contains the conclusions drawn from the analyses and findings. Associated recommendations are made, as appropriate.

CONCLUSIONS

7.2 The ability of a ship to accomplish all required work (at-sea and in-port work load) may be significantly enhanced through the use of organization-level alternatives other than manning increases. With relatively conservative changes in the ship's organization and work-load distribution, it is possible to reduce deferred organic maintenance to a level that can be easily scheduled and accommodated by off-ship support facilities.

7.3 The effectiveness of an absolute work-load reduction in improving the capability of a ship to accomplish its work load can be increased greatly if the reduction is systematically applied and is made in conjunction with other improvement alternatives, such as intraship work-load transfers.

7.4 Scheduling methodologies currently available to shipboard managers are inadequate to support the work-load scheduling required to eliminate unnecessary peaks in deferral.

7.5 The scheduling of in-port maintenance as depicted in the notional work packages will, in itself, provide no direct reduction in expected deferral. Indirect benefits, such as better management of maintenance, are expected to result.

7.6 Preliminary/interim work packages provide insufficient guidance to shipboard managers concerning the efficient assignment of generic ships' force work load (e.g., fire watches) to work centers.

7.7 The actual improvement in organic maintenance capability achievable through the use of new FM concepts will be significantly affected by the rationale used to determine the size, composition, and total work load of the FM teams. Assigning only FM to the FM teams and constructing the teams by drawing billets from existing work centers based on the original distribution of FM among work centers will result in a less efficient utilization of personnel than can be achieved by assigning additional non-rating-sensitive work load to the FM teams and drawing billets from work centers based on the work load versus capability balance for each work center.

7.8 Formal organizations that are based on functional aggregations by work category and skill level provide the best opportunity for managing and controlling potential deferral problems, provided that work load/functions are not so narrowly defined that the number of work centers is significantly increased.

RECOMMENDATIONS

7.9 The following paragraphs present the recommendations of this report. First, an improved scheduling methodology should

be developed and installed for use at the shipboard division level and above. The methodology should be used by shipboard managers to schedule all non-watchstanding work load, including PM, noncritical CM, FM, UT, and A/S, with full consideration of the parameters that impact on the work load and capability of each work center. The objective should be to reduce the significant peaks in deferral that occur throughout the operational schedule of the ship. Fluctuations in work load and capability that occur as a result of the dynamic nature of ship operations and changing environments currently cannot be accurately predicted by shipboard managers, and, hence, proper scheduling cannot take place. As a result, unnecessarily high levels of deferral exist periodically, potentially limiting the ability of the ship to readily convert to a wartime posture.

7.10 A formal, approved prioritization list should be developed and promulgated, depicting the relative priorities of work categories and/or subsets of work categories as well as detractors. Such a list is required to ensure that the impacts of various initiatives are adequately anticipated. For example, if an initiative is undertaken to reduce the man-hour expenditures required by the ship to accomplish planned maintenance and the objective is to either increase the percentage of planned maintenance (or any other category of work) actually performed or to allow for the same percentage to be performed by a reduced work force, there is no assurance that the objective will be met, even though the planned maintenance work load is reduced. Rather, the capability made available by the reduction in planned maintenance work load might be used by the ship to increase the amount of training actually accomplished or to improve the ability of the ship to comply with current Navy policies regarding the granting of leave.

7.11 The rationale used to form FM teams from existing ship manning should be based on the work load versus capability balance of each work center in the ship and not only on the amount of FM currently assigned to each work center. FM teams consisting of a rotating pool (similar to the concept used for mess cooking) appears feasible. The training allowance for FM teams should include the FM-specific training requirements, as well as the training requirements necessary for each team member to remain proficient or to strike for a rating. In addition to FM, FM teams should be assigned other non-rating-sensitive work load (e.g., SN/FN watches, PM and UT) to efficiently utilize the work force.

7.12 Work packages describing in-port maintenance work should include statements as to the potentially most efficient method of assigning generic ships' force work (e.g., fire watches) to work centers. The ship's Commanding Officer should retain the flexibility to assign the work as he sees fit; however, information should be provided concerning the considerations that must be included in the assignment strategy that are not now obvious.

7.13 On implementation of the new FM and RCM concepts, transfers of other work load among work centers should be specified to maximize the benefits occurring as a result of the new concepts.

7.14 Principles of functional analysis should be integrated into the ship manpower planning process. The standard unit organization as described in OPNAVINST 3120.32 is based on battle requirements and, therefore, defines a formal organization consisting of functional groups that are established primarily according to the controlling station during battle.

The automatic use of this organization by manpower planners limits the opportunity to maximize the efficient use of manpower resources.

7.15 Formal policies should be established regarding the feasibility and necessity of transferring work from work center to work center and cross-utilizing personnel. Tradition and precedent form strong barriers that must be broken if efficient manpower utilization is to occur. High-level visibility of this problem is required. The following is an example of such a policy statement:

> Traditionally, Navy men and women have taken pride in the ability of their work center, division, department and unit to accomplish all required work without outside assistance. Similarly, precedent and tradition have led to the categorization of some work, facilities maintenance for example, as primarily the responsibility of junior enlisted personnel, while other work, such as routine supervision, has been established as the domain of senior petty officers.
>
> The overall effect has been the compartmentalization of work into rigid blocks based on the perceived necessity for a certain rate and rating to accomplish the tasks.
>
> In an era where a compact, technically oriented Navy is a fact of life, ship manpower planners face the challenge of manning ships with the skills required for combat while simultaneously attempting to provide those personnel needed in a peacetime environment. Clearly certain trade-offs are necessary, and, appropriately, the combat-associated requirements must have priority. Even where wartime and peacetime manpower requirements are nearly identical, budgetary constraints and/or accession and retention difficulties may lead to fluctuations in manning levels.

It is the Navy's official policy that optimum utilization of all resources occur. At the shipboard level, efficient use of manpower can occur only if increased flexibility relative to work-load assignment and cross-utilization of personnel becomes a reality. Work-center supervisors, division officers and department heads must analyze work loads and capabilities and, where necessary, reassign responsibility for certain tasks to those qualified and able to accomplish the work, even though barriers set by tradition or precedent must be overcome. Pride of accomplishment must be based on the ability of the ship as a whole to perform all required work and not on the ability of individual work centers or divisions to be self-sustaining while work remains to be done elsewhere on the ship.

APPENDIX A
SHIP WORK LOAD ALGORITHM

A.1 The algorithm is a time-staged comparison of work load and capability throughout the phases of the operational schedule (OPSKED). Its function is to compute the difference between work load and capability for each phase of the designated OPSKED and then to appropriately accumulate both the deferred work load man-hours and the slack (undertasked man-hours) over the period of the full schedule or any prescribed portion thereof. The output provides a means for evaluating the impact of various alternative work load and capability variables. The algorithm as described below is basically the same as the algorithm originally developed during the FMPS, with minor output changes having been made to increase its utility.

GENERAL DESCRIPTION

A.2 A graphic overview of the basic algorithm is presented in Figure A.1. As a variety of input items that affect work load, capability, or both are introduced, the algorithm separately computes the work load and capability values thus generated for each work center and proceeds with the comparative process to produce the basic man-hour difference. The man-hour values are, in turn, subjected to an iterative process to determine, within one-half billet, the number of billets that would have to be added to or deleted from the work center to provide zero ending deferral. The undertasking, if any, generated by the manning change for zero ending deferral also is computed in man-hours.

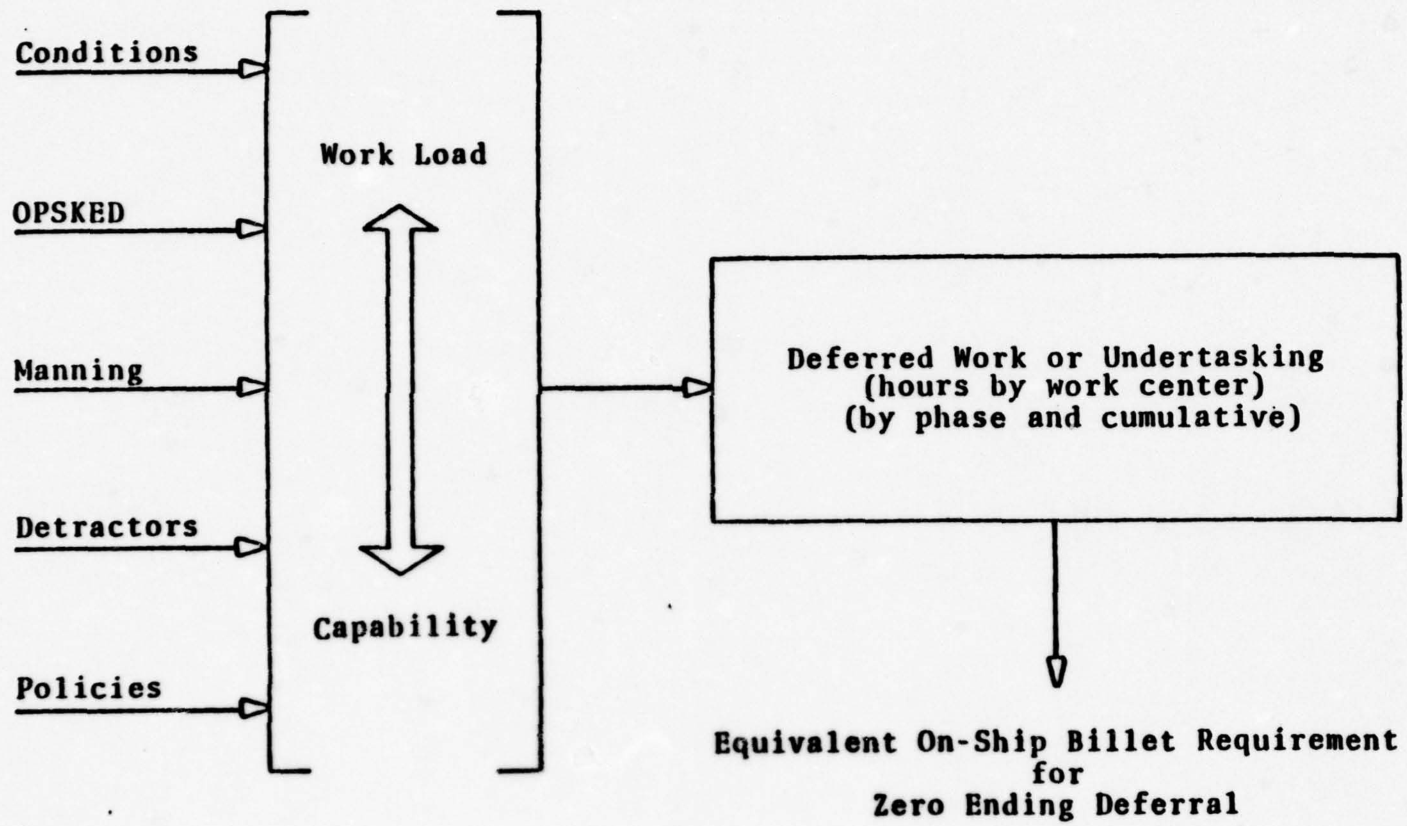

FIGURE A.1
BASIC ALGORITHM

Input

A.3 The primary input items, and thus the dimensions used for sensitivity analysis, are as follows:

- At-sea and in-port conditions
- Order and duration of phases of the OPSKED
- Personnel manning level (SMD requirement, manpower authorization (OPNAV 1000/2), actual ship manning level, or other specified level)
- Training requirements (SMD allowance or empirically developed values)
- Variation from the base work load values as a function of the phase of the OPSKED
- Detraction factors, i.e., unauthorized absences (UAs), leave, temporary additional duty (TAD), etc.

Output

A.4 The output of the algorithm includes work deferral and/or undertasking for each work center in man-hours by phase, cumulative deferral at the end of the planning horizon(s), and the corresponding work center manning level change for an ending zero deferral.

A.5 Summary Report. The results of each simulation are summarized in a report with the elements of information described below. Table A.1 is a random extract from an actual report and is presented to serve as an example of the various report elements.

A.6 Reading from left to right, the report elements are explained as follows:

TABLE A.1
EXTRACT OF SUMMARY REPORT

33 SSSN — SUMMARY REPORT

WORKCENTER	WEEK	WORKLOAD TOTAL	WORKLOAD AVERAGE	DEFERRAL TOTAL	DEFERRAL PERCENT OF TOTAL WORK LOAD	DEFERRAL PER BILLET PER WEEK	CAPABILITY TOTAL	CAPABILITY PER BILLET PER WEEK	BASAL SLACK TOTAL	BASAL SLACK PERCENT OF CAPABILITY	BASAL SLACK PER BILLET PER WEEK
	40	8818.55	220.46	61.18	.6	.25	8863.81	36.93	106.44	1.2	.44
	73	16861.60	230.98	392.80	2.3	.89	16881.84	38.54	413.06	2.4	.94
	82	18487.90	225.46	511.96	2.7	1.06	18388.98	37.37	413.04	2.2	.83
	120	27923.85	232.70	86.46	.3	.12	28250.43	39.23	413.04	1.4	.57
	139	32703.00	235.27	13.24	.0	.01	33264.44	39.88	574.68	1.7	.68
	154	36392.30	236.31	299.86	.8	.32	36769.06	39.79	676.62	1.8	.73
	163	38018.60	233.24	419.02	1.1	.42	38276.20	39.13	676.62	1.7	.69
	198	46423.05	234.46	130.68	.2	.11	46964.99	39.53	676.62	1.4	.56
	225	53137.20	236.17	.00	.0	.00	53988.96	39.99	951.76	1.5	.63
	234	54763.50	234.03	459.00	.8	.32	55156.26	39.20	851.76	1.5	.60

WEEK	BILLETS TO ELIM DEFERRAL RANGE		BILLETS TO ELIM DEFERRAL MAXIMUM	RESULTANT SLACK RANGE	
40	.00	.44	.44	106.4	723.40
73	6.00	6.15	6.15	17539.3	17967.54
82	1.50	2.00	6.15	4694.6	6279.68
120	.00	.50	6.15	413.0	2765.23
139	.00	.50	6.15	574.6	3428.53
154	1.00	1.50	6.15	6780.9	9831.02
163	.50	1.00	6.15	3728.8	6864.78
198	.00	.50	6.15	676.6	4596.67
225	.50-	.00	6.15	.0	851.76
234	2.00	2.50	6.15	19456.8	24185.17

- <u>Work Center</u>--Identified by number and by division-rating code.

- <u>Week</u>--Identifies the various weeks in the OPSKED that were selected as the review points. Each value defines a separate planning horizon, beginning with the first week of the schedule. The last value listed always identifies the last week of the OPSKED used.

- <u>Total Work Load</u>--Values reflect the total required work load of the work center for the number of weeks shown in the previous column.

- <u>Average Work Load</u>--Total work load values are divided by the number of weeks, to derive the average weekly work load over the period indicated.

- <u>Total Deferral</u>--Values reflect the cumulative hours of deferred work over the number of weeks indicated.

- <u>Deferral as a Percent of Work Load</u>--Values reflect the total deferral divided by the total work load and multiplied by 100.

- <u>Deferral Per Billet Per Week</u>--Values reflect the total deferral divided by the product of the number of billets in the work center and the number of weeks indicated.

- <u>Total Capability</u>--Values reflect the cumulative productive capability of the work center over the number of indicated weeks.

- <u>Capability Per Billet Per Week</u>--Values reflect the total capability divided by the product of the number of billets in the work center and the indicated number of weeks.

- <u>Total Basal Slack</u>--Values reflect the cumulative hours of undertasking, i.e., hours of capability that were in excess of the total required phase work load. (It is referred to as basal slack to distinguish the values from the slack values that result from simulated manning changes to the work center, explained under "resultant slack" below.)

- <u>Basal Slack as a Percent of Capability</u>--Values reflect the cumulative amount of undertasking divided by the total capability for the stated period and multiplied by 100.

- <u>Basal Slack Per Billet Per Week</u>--Values reflect the cumulative amount of undertasking divided by the product of the number of billets in the work center and the indicated number of weeks.

- <u>Billets to Eliminate Deferral</u>--Value in the <u>maximum</u> column is the greatest difference, in terms of the billet equivalent of the deferred work or undertasking, for any phase encompassed by the period. Values under <u>range</u> identify, within one-half billet, the change in manning which, if applied over the full number of weeks in the period, would result in a zero ending work deferral.

- Resultant Slack Range--Values show the total cumulative hours of undertasking that will be encountered with the respective low and high value manning changes in the previous two columns.

Algorithm Organization

A.7 The algorithm is partitioned into two computational stages. First, the productive work load and capability differences, measured in man-hours, are established for each work center for each week of the schedule. The productive weekly differences, collected by phase, serve as the computational unit for the next stage of the algorithm.

A.8 The second stage of the algorithm incorporates the concept of cumulative deferral. To compute the cumulative deferral leaving the present phase, *the deferral from the previous phase* is algebraically added to the work load/capability imbalance of the present phase. If a positive imbalance exists in the present phase, this difference is termed deferral and is carried forward to the next phase. If a negative imbalance results, this constitutes undertasking for the present phase, and no deferral is carried forward to the next phase.

Feasibility Criteria

A.9 The algorithm is designed to accept various input parameters and determine the minimum work center manning level requirements necessary to achieve zero cumulative deferral. As mentioned, another primary output of the algorithm is the cumulative deferral remaining if no adjustments are made to the work center manning level. It is important, however, that the manning level selected for a particular application of the algorithm meet certain feasibility criteria.

A.10 The driving factors regarding feasibility are the maximum number of watchstanders encountered in the prescribed conditions under analysis and the work center manning level. If the manning level falls below the maximum number of watchstanders required, the work center manning level is insufficient on the basis of the watchstander requirements for the governing conditions.

A.11 As a result, the algorithm will not compute a manning level change for zero cumulative deferral on a work load/capability basis that violates the watchstander requirements. For work centers so affected, however, the algorithm <u>will</u> compute the deferred work or undertasking that results from the decision to underman the work center on a watchstander basis.

<u>Capability Computation</u>

A.12 The computation of capability is a process of determining the total time available to the work center, by virtue of having provided a number of billets, and then subtracting the time lost to detractions. The remainder is the time available for productive effort and constitutes capability. The separate elements and the computation of productive capability are described in the following paragraphs.

A.13 <u>Total Available Time</u>. The two factors that determine total available time TAT for the work center are the number of watchstanders/non-watchstanders and the length of the workweek. TAT is calculated as follows:

$$\begin{aligned} \text{TAT} = &\ (\text{number of watchstanders}) \\ &\times (\text{watchstanders workweek}) \\ &+ (\text{number of non-watchstanders}) \\ &\times (\text{non-watchstander workweek}). \end{aligned} \qquad \text{(A.1)}$$

To illustrate at-sea availability, assume a work center has 10 billets, 2 of which are watchstanders. If present SMD policy requirements for at-sea workweeks are used, the TAT for this at-sea week in Condition III for the work center is computed as shown in Equation (A.1). Using these watchstander/non-watchstander values of 2 and 8, respectively, and the associated workweeks, the TAT, using Equation (A.1) is computed as follows:

$$TAT = (2)(74) + (8)(66) = 676 \text{ man-hours.}$$

A.14 Total Productive Capability. Total productive capability for the work center is the amount of weekly time available for productive work. It is determined by the relationship expressed in the following equation:

$$\text{Total productive capability} = \text{total available time} - \text{detractions} \qquad (A.2)$$

where:

$$\begin{aligned}\text{Detractions} = {} & \text{unauthorized absences} \\ & + \text{temporary additional duty} \\ & + \text{service diversions} \\ & + \text{training} \\ & + \text{leave.} \qquad (A.3)\end{aligned}$$

A.15 Detractors. Considerable flexibility is present for using productivity detractors, both in the variety included and the number of value options.

A.16 Unauthorized Absences, Temporary Additional Duty, and Service Diversions. Values for unauthorized absences (UA) and

temporary additional duty (TAD) are provided in hours per week per billet and multiplied by the number of work center personnel to determine the total amount of detraction time created by these categories. Service diversion values may be specified or dictated by SMD policy (which presently assigns the amount per billet based on the ship's condition) and the billet's watch status (watchstander/non-watchstander). [1/]

A.17 Returning to the example problem, if 0.5 hr per week per billet is used for UA, 0.4 hr per week per billet for temporary additional duty, and SMD policy applied for service diversions, then the following detraction values for the work center would result:

- UA = (0.5) (10) = 5 man-hours
- TAD (other) = (0.4) (10) = 4 man-hours
- Service diversions = (2.50) (2)
  + (3.00) (8)
  = 29 man-hours.

A.18 Training. Two alternative computational techniques are provided for determining the work center training requirements. The first assigns the training allowance specified in present SMD policy to each billet on the basis of the ship's condition and the billet's watch status in the condition.

A.19 The second computes the requirement using training requirement data specified by the user. In computing and applying the training requirements under this alternative, the algorithm deals appropriately with that training that is fixed for the work center (i.e., not directly related to work center manning) and that which varies directly with the work center manning level. The two approaches are illustrated in Figure A.2.

[1/] For example, the present SMD policy for the service diversion allowance in Condition III is 2.5 hr per week per billet for watchstanders and 3.0 hr per week per billet for non-watchstanders (OPNAV 10P-23).

Final Data Organization for Entry into Algorithm

Work Centers	Cond. III		Cond. IV		Cond. V	
	WS	NWS	WS	NWS	WS	NWS
AMM						
AEN						
BBT						

-- Hours/week/men

-- Adjustable by algorithm

-- Method 2 not sensitive to WS/NWS

-- Accommodates no. of wk IP/yr

Training Option: Method 1

Cond. III		Cond. IV		Cond. V	
WS	NWS	WS	NWS	WS	NWS

All Work Centers

Method 2

a. Ship level
b. Higher authority
c. Composite total of a & b

Work Centers	On Board	Off Ship
AMM		
AEN		
BBT		

FIGURE A.2
TRAINING DATA ORGANIZATION

A.20 To compute the training requirement for the example problem, using this second technique, assume values as assigned below:

- On-board fixed training for the work center is 15 hr/wk
- On-board basic requirement for each work center billet is 2.5 hr/wk/billet

For a ship at-sea, the following equation applies.

$$\text{Training requirement (at-sea)} = \text{on-board training} \qquad \text{(A.4)}$$

where:

$$\begin{aligned}\text{On-board training} = {} & \text{(number of work center billets)} \\ & \times \text{(basic on-board requirement for each billet)} \\ & + \text{(fixed on-board requirement for work center).}\end{aligned}$$

A.21 Applying the values of the example problem,

$$\text{On-board training} = (10)(2.5) + 15 = 40 \text{ hr.} \qquad \text{(A.5)}$$

Therefore, the training requirement for the work center equals 40 hr for the week. Had the ship been in port, the off-ship requirement would have been added to the on-board requirement as shown below.

$$\text{Training requirements (in port)} = \text{off-ship} + \text{on-board} \qquad \text{(A.6)}$$

where the off-ship training for the work center is equal to the sum of the fixed off-ship annual requirement plus the basic off-ship annual requirement (annual requirement for billet times the number of billets), all divided by the number of in-port weeks per year.

A.22 Leave. There are four leave options provided. They include: Option 1, actual experience by phase; Option 2, actual average leave; Option 3, a combination of Options 1 and 2; and Option 4, the number of days of leave per year allowed by policy. Options 1, 2 and 4 are illustrated in Figure A.3. The first three options are expressed in hours per week per billet. When they are entered into the computations, the algorithm simply accepts the values of the selected option as assigned to the work centers and phases under analysis.

A.23 The third leave option is a modification to Options 1 and 2. The leave taken by ship's personnel can be represented, with reasonable accuracy, by three leave factors. One factor is applied to all personnel during at-sea phases. A second factor is applied to most in-port phases. The third factor is applied to only one in-port phase (LVUPK) during which time 50 percent of each work center is assumed to be on leave.

A.24 In the FMPS the average leave factor for all in-port phases was computed at 3.247 hr/bil/wk. For all at-sea phases the average leave factor was found to be 1.449 hr/bil/wk. To achieve additional accuracy, the overall in-port leave factor may be broken down into leave during LVUPK and leave during all other in-port phases. For example, in the FF-1052 OPSKED used in this study there are 12 wk of LVUPK, 120 wk of other in-port phases and 102 wk of at-sea phases. If it is assumed that the

Final Data Organization for Entry Into Algorithm

Work Centers	At Sea					In Port			
	TYT	UNREP	En Route	Transit	Deploy	Upkp	TAV	Load	Stand-down
AMM									
AEN									
BBT									

--hour/week/man

Leave Options

Actual Experience

(Same format as above)

Actual Average Leave

(Computed average applied to all work centers and phases)

Y Days/Yr Allowance

Allowance as function of days of leave allowed per year and no. of weeks ship in port applied equally to all work centers and phases

FIGURE A.3

LEAVE DATA ORGANIZATION

leave factor is 20.5 hr/bil/wk (50% of the non-watchstander workweek) during LVUPK, the leave factor for the remaining in-port phases may be calculated from the following equation:

$$\frac{(LFL \times NL) + (LFO \times NOIP)}{NL + NOIP} = AIPLF \qquad (A.7)$$

where,

LFL = the leave factor for LVUPK

NL = the number of weeks the ship is in LVUPK

LFO = the leave factor for all other in-port phases

NOIP = the number of weeks the ship is in all other in-port phases

AIPLF = the average in-port leave factor.

Substituting the known information into A.7 yields:

$$\frac{(20.5 \times 12) + (LFO \times 120)}{12 + 120} = 3.247.$$

Solving for LFO, the leave factor for all other in-port phases is 1.520 hr/bil/wk. The leave factors are summarized below:

Phase	Leave Factor (hr/bil/wk)
At-sea phases	1.449
LVUPK	20.500
All other in-port phases	1.520

A.25 These factors reflect the assumption that 50 percent of each work center is granted leave during LVUPK. With only half of the work center present, the amount of UA, TAD, service diversions and variable training associated with the work center

must be modified to reflect the fact that the amount of time during which a billet may encounter the detractions is limited to the length of the workweek minus leave and fixed training.

A.26 The approach taken is to calculate the ratio of time actually available for UA, TAD, service diversions and variable training (hereafter referred to as variable detractor time VDT) to the time allowed for these detractors during normal leave phases. By assuming this ratio to be constant, the allowance for these detractors during LVUPK may be calculated.

A.27 The allowance for UA, TAD, service diversions and variable training during LVUPK is calculated from the following equations.

$$\frac{VDT_{ONWS}}{VD_{ONWS}} = R_{NWS} \tag{A.8}$$

$$\frac{VDT_{OWS}}{VD_{ONWS}} = R_{WS} \tag{A.9}$$

$$\frac{VDT_{LNWS}}{R_{NWS}} = VD_{LNWS} \tag{A.10}$$

$$\frac{VDT_{LWS}}{R_{US}} = VD_{LWS} \tag{A.11}$$

where,

VDT_{LNWS} = the variable detraction time of a non-watchstander during LVUPK

VDT_{LWS} = the variable detraction time of a watchstander during LVUPK

VDT_{ONWS} = the variable detraction time of a non-watchstander during all other in-port phases

VDT_{OWS} = the variable detraction time of a watchstander during all other in-port phases

VD_{LNWS} = the allowance for all detractors, excluding fixed training and leave, of a non-watchstander during LVUPK

VD_{LWS} = the allowance for all detractors, excluding fixed training and leave, of a watchstander during LVUPK

VD_{ONWS} = the allowance for all detractors, excluding fixed training and leave, of a non-watchstander during all other in-port phases

VD_{OWS} = the allowance for all detractors, excluding fixed training and leave, of a watchstander during all other in-port phases

R_{NWS} = the ratio of accountable time to the allowance for all detractors, excluding fixed training and leave, for a non-watchstander

R_{WS} = the ratio of accountable time to the allowance for all detractors, excluding fixed training and leave, for a watchstander.

A.28 Equations (A.8) and (A.9) are solved for R_{NWS} and R_{WS} respectively. Then (A.10) and (A.11) may be solved for VD_{LNWS} and VD_{LWS} respectively. The calculations must be performed for each work center.

A.29 Define ANWS = the number of assigned non-watchstanders in a work center

AWS = the number of assigned watchstanders in a work center, and

ADID = the average difference in allowance for variable detractors per billet between LVUPK and all other in-port phases.

Then:

$$ADID = \frac{ANWS\ (VD_{ONWS} - VD_{LNWS}) + AWS\ (VD_{OWS} - VD_{LWS})}{ANWS + AWS}. \tag{A.12}$$

As a matter of programming convenience the appropriate ADID for a given work center is subtracted from the 20.5 hr/bil/wk and this difference is used as the leave factor during LVUPK.

A.30 For example, consider the work center NQM. Here, AWS = 1, ANWS = 4, VDT_{ONWS} = 36.46, VDT_{OWS} = 40.46, VD_{ONWS} = 10.23, VD_{OWS} = 10.08, VDT_{LNWS} = 17.48, VDT_{LWS} = 21.48.

Then: $$R_{NWS} = \frac{VDT_{ONWS}}{VD_{ONWS}} = \frac{36.46}{10.23} = 3.56$$

$$R_{WS} = \frac{VDT_{OWS}}{VD_{OWS}} = \frac{40.46}{10.08} = 4.01$$

$$VD_{LNWS} = \frac{VDT_{LNWS}}{R_{NWS}} = \frac{17.48}{3.56} = 5.36$$

$$VD_{LWS} = \frac{VDT_{LWS}}{R_{WS}} = \frac{21.48}{4.01} = 4.91$$

$$ADID = \frac{ANWS\ (VD_{ONWS} - VD_{LNWS}) + AWS\ (VD_{OWS} - VD_{LWS})}{ANWS + AWS}$$

$$= \frac{4(10.23 - 5.36) + 1\ (10.08 - 4.91)}{5} = 5.20$$

The leave factor used during LVUPK is then 20.5 - 5.20 = 15.30. The baseline leave factors for all work centers during LVUPK are contained in Table 2.9 for the FF-1052 class and Table 2.10 for the FFG-7 class.

A.31 To apply the fourth leave option, the number of days of leave allowed by policy, the basic values must be converted into the proper dimensions. The transformation is performed with this expression:

$$\frac{\left[(x)\ (41) + (52 - x)\ (66)\right](D)}{(52)\ (52)\ (7)} \qquad (A.13)$$

where:

x = number of in-port weeks per year
(52-x) = number of at-sea weeks per year
D = days of leave allowed per year
66 = non-watchstander workweek at sea
41 = non-watchstander workweek in port.

A.32 For example, if the ship averages 26 wk in port per year and 20 days leave is allowed by policy, the value computed by the expression is:

$$\frac{[(26)(41) + (52-26)(66)](20)}{(52)(52)(7)} = 2.94 \text{ hr/wk/billet.}$$

The amount of leave for the 10-man work center in the example problem then would be:

(10)(2.94) = 29.4 hr/wk for this detraction category.

A.33 Recalling Equation (A.2), in which the total productive capability was equal to the total available time minus detractions, the computation of total productive capability can now be illustrated, using the example values for the appropriate elements bearing on capability as summarized below:

- Total available time: 676 man-hours
- Total detractors: 107.4 man-hours
  - Service diversions (29 man-hours)
  - Unauthorized absences (5 man-hours)
  - Temporary additional duty (4 man-hours)
  - Training (40 man-hours)
  - Leave (29.4 man-hours)

Total productive capability = 676 - 107.4
= 568.6 man-hours/week. (A.14)

A.34 A final restriction on the capability equation, expressed as "total productive capability is greater than or equal to zero," precludes the computation of an unrealistic negative work center capability. The values of the example problem meet this test of feasibility.

Work Load Requirements Computation

A.35 Work Categories. For a given week of the schedule, the basic work requirement for the work center is expressed in at-sea and in-port values for the work categories listed below:

- Preventive maintenance (PM)
- Make-ready/put-away (MR/PA)
- Corrective maintenance (CM)
- Facilities maintenance (FM)
- Administration and support (A/S)
- Utilities task (UT)
- Customer support (CS).

A.36 Work Load Variance. If the impact of variance in any work category is desired, the percent of variance is multiplied by the average or normal work requirement in-port or at-sea, as appropriate, and the product is algebraically added to the normal requirement. For example, continuing the problem as discussed in the capability section, assume a 50% positive variance in PM is estimated for the at-sea phase and that the average or normal PM requirement for the work center is 100 hr per week. The total PM for the week would now be 150 hr (100 + 0.50 x 100). Further, since the present SMD methodology defines MR/PA as 30% of the PM requirement, this category would increase accordingly. For the example problem, since the basic PM value is 100 hr, the MR/PA time associated with performing the PM is 30 hr. A 50% increase in PM produces a 50% increase in the associated MR/PA time. This constitutes an increase of 15 hr, bringing the total time allowed for MR/PA to 45 hr for the week.

A.37 Productive Allowance. A productive allowance of 20% of the work category requirements is established by SMD policy.

A.38 Operational Manning Requirements. By specifying the ship's condition for the week, the operational manning requirements for a week of an in-port or at-sea phase are determined. The conditions permitted in the algorithm are Conditions III or IV for at-sea phases and Condition V cold iron or auxiliary steaming for in-port phases.

A.39 The effects of the foregoing discussion on work load are summarized in Equation (A.15):

$$\begin{aligned}\text{Basic weekly work load} &= \text{category work} + \text{variation}\\ &+ \text{productive allowance}\\ &+ \text{operational manning.}\end{aligned} \tag{A.15}$$

The relationship is augmented by the following significant element-deferred work.

$$\begin{aligned}\text{Total weekly work load} &= \text{category work} + \text{variation}\\ &+ \text{productive allowance}\\ &+ \text{operational manning}\\ &+ \text{deferred work.}\end{aligned} \tag{A.16}$$

Deferred Work or Undertasking

A.40 Deferred work occurs when there is a positive difference in work load relative to capability, i.e., the previous week's total weekly work load exceeds the total productive capability. If a negative difference occurs (more productive capability than total work load), the value represents slack time or undertasking, and the deferral from the previous week is zero.

Zero Cumulative Deferral Computation

A.41 Algorithmic Procedure. For each week of the schedule, the following equation is applied.

Productive difference for week = basic weekly work load - weekly productive capability. (A.17)

The productive difference is summed over each week of the phase and organized for further manipulation. To initiate the algorithm, the entering deferral for the first phase is set equal to zero.

A.42 Equivalent Billets to Eliminate Deferral. The computed phase difference is in terms of productive hours. Therefore, to establish a manning level change to accommodate the difference, the manning change must be made in terms of available productive hours per billet. The man-hour value of each equivalent billet is defined in Equation (A.14). The assumption is that all changes to work center manning levels are in terms of non-watchstander billets. The productive capability (PC) provided by an equivalent billet (man-hours per week) is expressed as follows:

PC = non-watchstander workweek
- service diversion factor for non-watchstanders
- unauthorized absence factor
- temporary additional duty factor
- leave factor
- basic training requirement for each work center billet (Method 2) or current policy requirement for non-watchstanders (Method 1), as appropriate. (A.18)

Because of the preceding factors, the PC that an equivalent billet takes on during a particular week may vary by phase, rating, ship status and condition.

A.43 Numerical Illustration. To illustrate the fundamental computational procedures of the algorithm, a numerical example is provided. Let the productive hours per week per billet for all in-port phases equal 35 hr and the productive hours per week per billet for all at-sea phases equal 50 hr. Table A.2 shows the results of the procedure up to this point in the development.

A.44 Table A.3 represents a numerical summary illustrating the various levels of computation necessary to arrive at the ending deferral at the present manning level, the required number of billets to eliminate this deferral, and the slack or undertasking associated with either decision.

A.45 The table is divided into seven columns. The first column, termed "operation," represents a change in work center manning level. The values in the second column, "phase number," and fourth column, "phase difference," correspond to those located in Table A.2 under the same titles.

A.46 The cumulative deferral calculations are in two parts. The deferral entering the phase is located in Column 3 and the deferral leaving the phase in Column 6. In the example, for the operation of "add 0 billets," the deferral entering Phase 1 is zero. By assumption, the deferral entering Phase 1 is always zero.

TABLE A.2

PHASE COMPUTATION SUMMARY

				Phase		
Phase Number	Ship Status	Phase Name	Number of Weeks	Difference, hr	Equivalent Billet Value, hr*	Difference in Equivalent Billets**
1	AS	Local operating	4	200	200	1.00
2	IP	Upkeep	2	100	70	1.43
3	AS	Transit	1	-50	50	-1.00
4	IP	POM	2	100	70	1.43
5	AS	Deploy	24	1,000	1,200	0.83
6	IP	Stand down	4	50	140	0.36

* Either number of weeks x 35 in port or number of weeks x 50 at sea.

** Phase difference in hours divided by phase equivalent billet value.

TABLE A.3
NUMERICAL SUMMARY FOR BILLET DIFFERENTIAL CALCULATIONS

Operations	Phase Number	Cumulative Deferral Entering Phase, hr	Phase Difference, hr	Capability Change, hr	Cumulative Deferral Leaving Phase, hr	Resultant Slack, hr
Add 0 billets	0 (start)	0	--	--	--	--
	1	+0	+200	-0 x 200 = 0	+200	0
	2	+200	+100	-0 x 70 = 0	+300	0
	3	+300	-50	-0 x 50 = 0	+250	0
	4	+250	+100	-0 x 70 = 0	+350	0
	5	+350	+1,300	-0 x 1,200 = 0	+1,650	0
	6	+1,650	+50	-0 x 140 = 0	+1,700	0
Total	--	--	--	--	--	0
Add 1 billet	0 (start)	0	--	--	0	--
	1	0	+200	-1 x 200 = -200	0	0
	2	0	+100	-1 x 70 = -70	+30	0
	3	30	-50	-1 x 50 = -50	0	70
	4	0	+100	-1 x 70 = -70	+30	0
	5	+30	+1,300	-1 x 1,200 = -1,200	+130	0
	6	+130	+50	-1 x 140 = -140	+40	0
Total	--	--	--	--	--	70
Add 2 billets	0 (start)	0	--	--	0	--
	1	0	+200	-2 x 200 = -400	0	200
	2	0	+100	-2 x 70 = -140	0	40
	3	0	-50	-2 x 50 = -100	0	150
	4	0	+100	-2 x 70 = -140	0	40
	5	0	+1,300	-2 x 1,200 = -2,400	0	1,100
	6	0	+50	-2 x 140 = -280	0	230
Total	--	--	--	--	--	1,760
Add 1.5 billets	0 (start)	0	--	--	0	--
	1	0	+200	-1.5 x 200 = -300	0	100
	2	0	+100	-1.5 x 70 = -105	0	5
	3	0	-50	-1.5 x 50 = -75	0	125
	4	0	+100	-1.5 x 70 = -105	0	5
	5	0	+1,300	-1.5 x 120 = -1,800	0	500
	6	0	+50	-1.5 x 140 = -210	0	160
Total	--	--	--	--	--	875

A.47 Next, the entering deferral is added to the phase difference to establish the total imbalance for the phase. If additional capability is added to the work center by the operation, the amount of the capability is subtracted from the total phase imbalance to determine any imbalance remaining after the operation. If, by application of the procedures described, the imbalance is positive, this would constitute a leaving deferral from the phase. If, however, the imbalance is negative, the leaving deferral is zero, and an undertasking has resulted in the work center. This undertasking is listed in Column 7 under the heading "slack."

A.48 Interpretation of the Table. Viewing the four stages of operations, notice that the first two, "add 0 billets" and "add 1 billet," possess a positive ending deferral at the end of the planning horizon. However, also note that the operation of "add 2 billets" is the first integer change that will produce a zero ending deferral. To determine whether an exact fractional manning solution lies closer to the operation "add 1 billet" or "add 2 billets," the operation "add 1.5 billets" is performed. Because this fractional solution lies between adding 1 billet and adding 1.5 billets, additional splitting techniques could be used to straddle the exact fractional solution within tighter boundaries.

A.49 Referring back to Table A.2, the maximum value that the phase billet takes on is 1.43. Note that this particular statistic, if applied as an operation, always produces zero ending deferral. It is the "peak" manning solution. Thus, the exact fraction solution lies in the interval between "add 1 billet" and "add 1.43 billets." Indeed, the exact fractional solution lies very near "add 1 billet," which has an ending deferral of only 40 hr as opposed to the "add 0 billets" operation, which has an ending deferral of 1,700 hr.

A.50 An attribute of the algorithm provides, in essence, that up to 10 planning horizons for each simulation may be used. That is, the cumulative work load versus capability situation can be determined at 10 separate review points in the schedule, including the end-of-schedule results. This feature expands the analytical possibilities and provides more meaningful results with a relatively small number of simulations.

USE

A.51 Major analyses use the algorithm output as the basic indices for comparisons and findings. These, in turn, are used in numerous combinations to establish absolute differences, trends, and relative impacts with both single and multiple bases.

APPENDIX B
ESTIMATION OF CONDITION V FM AND OUS WORK LOAD: FFG-7

B.1 The FFG-7, unlike the ships included in the FMPS, was not activity sampled to determine the in-port work load. Since this information is essential to analyses with the ship work load (SWL) algorithm, it was necessary to develop estimates for those work categories (FM and OUS) for which empirical development of man-hour requirements was not possible.

APPROACH

B.2 The approach used to estimate Condition V FM and OUS work loads for the FFG-7 class was based on the following rationale:

a. The variations between Conditions V and III work loads on the FFG-7 class would be similar to those variations found to exist between the same conditions for other classes.

b. When comparing work loads between equivalent work centers on different classes, the closer the work center manning levels are to one another, the closer are the work loads.

B.3 The Condition V FM and OUS work-load data for the FFG-7 were estimated by multiplying the Condition III FM and OUS work load for each work center by a ratio of Condition V to Condition III work load for that work center and category. The appropriate ratio for each work category and work center

was developed from data available for the DDG-15 and FF-1053 (which were activity sampled during *in-port phases in the* Fleet Manpower Policy Study).

B.4 The Condition III to Condition V ratio for each work center and category on the FFG-7 was expressed as a weighted average of the Condition III to Condition V ratios for the analogous work center and category for the DDG-15 and the FF-1053. The relative weights applied to the ratios for the DDG-15 and the FF-1053 were designed to give more weight to a ship as the number of billets in a particular work center approached the number of billets in that same work center for the FFG-7.

B.5 The mathematics used to develop the Condition III to Condition V work load ratio for a particular work center and category are as follows:

$$R_G = W_D R_D + W_F R_F$$

where,

R_G = Condition III to Condition V ratio for the FFG-7

W_D = weight applied to the DDG-15 ratio

R_D = Condition III to Condition V ratio for the DDG-15

W_F = weight applied to the FF-1053 ratio

R_F = Condition III to Condition V ratio for the FF-1053.

The values of W_D and W_F reflect the similarity of the manning levels of the DDG-15 and the FF-1053, respectively, to the FFG-7's manning level and are calculated as follows:

$$W_D = \frac{1}{|M_G - M_D|} \times UF$$

$$W_F = \frac{1}{|M_G - M_F|} \times UF$$

where,

$$UF = \frac{|M_G - M_F| \times |M_G - M_D|}{|M_G - M_F| + |M_G - M_D|}$$

where,

M_G = SMD Condition III manning level of the FFG-7

M_F = SMD Condition III manning level of the FF-1053

M_D = SMD Condition III manning level of the DDG-15

UF = unity factor, which is a constant for that work center and forces the sum of the weights to equal one.

The following is an example of the calculations. Consider the OI OS work center and the FM work category. Data for the three ships is given in Table B.1.

TABLE B.1

SAMPLE DATA FOR THREE SHIPS: OI OS WORK CENTER

Ship	FM Condition III to Condition V Ratio	Manning
DDG-15	4.44	40
FF-1053	1.53	29
FFG-7	--	12

B.6 R_D is 4.44, and R_F is 1.53. The objective is to determine R_G.

$$|M_G - M_F| = 12 - 29 = 17$$

$$|M_G - M_D| = 12 - 40 = 28$$

$$UF = \frac{28 \times 17}{28 + 17} = 10.578$$

$$W_D = \frac{1}{28} \times 10.578 = 0.378$$

$$W_F = \frac{1}{17} \times 10.578 = 0.622$$

Therefore,

$$R_G = W_D R_D + W_F R_F$$

$$R_G = 0.378\ (4.44) + 0.622\ (1.53)$$

$$R_G = 2.63 = \text{Condition III to Condition V ratios for FFG-7}$$

$$1/R_G = 0.38 = \text{Condition V to Condition III ratio for FFG-7}$$

The Condition V FM work load for the OI OS work center is therefore estimated at 38% of the Condition III work load. The results for all work centers are shown in Table B.2.

TABLE B.2
FFG-7 FM AND OUS WORK LOADS

Work Center		FM			OUS				
		Ratio*	Work Load, hr/wk		Ratio*	UT Work Load, hr/wk		A/S Work Load, hr/wk	
Division	Rating	V:III	At Sea	In Port	V:III	At Sea	In Port	At Sea	In Port
SC1	QM	0.423	33.05	13.97	0.533	25.40	13.55	22.55	12.03
SC1	SM	0.962	63.23	60.80	1.064	17.06	18.15	8.73	9.29
SC2	RM	0.702	31.23	21.92	1.408	13.74	19.35	16.26	22.90
SC3	BM	1.429	353.62	505.17	0.901	160.28	144.40	55.20	49.73
CS1	OS	0.380	50.42	19.17	0.926	16.44	15.22	46.40	42.96
CS1	EW	0.344	10.69	3.67	1.010	1.04	1.05	0.00	0.00
CS2	ST	0.649	37.74	24.51	1.143	29.97	34.25	8.91	10.18
CS2	TM	1.000	0.00	0.00	0.590	16.23	9.58	0.00	0.00
CS3	FT	0.214	35.56	7.61	0.500	20.51	10.26	14.47	7.24
CS3	GMM	0.283	0.00	0.00	1.351	3.33	4.50	2.65	3.58
CS3	GMG	1.299	26.69	34.66	0.909	25.83	23.51	0.50	0.50
CS4	ET	1.266	19.62	24.84	1.481	22.04	32.65	16.93	25.08
CS4	DS	0.294	0.00	0.00	0.633	11.25	7.12	0.00	0.00
CS4	IC	0.372	9.80	3.64	1.156	11.08	12.81	0.40	0.46
E1	EN	0.543	29.11	15.82	1.587	23.32	37.02	38.43	61.00
E1	EM	0.188	16.15	3.03	0.870	7.49	6.51	3.86	3.36
E2	MR	0.905	0.00	0.00	0.165	6.50	1.07	0.90	0.15
E2	EN	0.543	111.32	60.50	1.587	26.11	41.44	2.10	3.33
E2	EM	0.358	60.52	21.69	0.690	34.24	23.61	5.00	3.45
E2	HT	0.341	5.17	1.76	0.459	29.83	13.68	3.79	1.74
S1	MA	1.000	0.00	0.00	0.000	2.08	0.00	43.32	0.00
S1	YN	0.649	22.98	14.92	0.735	0.42	0.31	91.24	67.09
S1	PN	0.162	0.00	0.00	0.442	2.08	0.92	46.43	20.54
S1	SK	0.096	34.47	3.31	0.389	4.58	1.78	135.29	52.64
S1	DK	0.462	11.49	5.31	0.484	1.46	0.71	17.54	8.49
S1	HM	0.375	0.00	0.00	0.493	2.08	1.02	25.87	12.74
S2	MS	0.605	196.70	119.07	0.478	28.56	13.65	410.93	196.43
S2	SH	0.631	78.71	49.63	0.482	13.33	6.43	168.48	81.27

* Values, as shown, have been rounded to three decimal places.

APPENDIX C
CALCULATION OF FF-1052 CLASS UTILITY TASKS AND ADMINISTRATIVE SUPPORT

C.1 The primary sources used to determine FF-1052 class baseline work loads combine the utilities tasks (UT) and administrative support (A/S) work loads into a single work category labeled own-unit support (OUS) for each work center. In a number of instances, it is desirable to deal with UT and A/S as separate entities. Accordingly, backup data for an FF-1052 class ship manpower document (SMD) were obtained and utilized to convert OUS into UT and A/S for each work center on the FF-1052 class. Table C.1 displays the UT and A/S values (hours per week) contained in the backup data, the percentage of the total represented by each quantity, the actual OUS values present in the baseline source (FF-1053 notional SMDs for Conditions IV and V as prepared by NAVMMACPAC) and the UT and A/S values for Conditions IV and V that result from multiplying the backup-data-generated percentages by the baseline source data.

TABLE C.1
FF-1052 CLASS UT AND A/S

Work Center		Backup Data				FF-1053 NSMDS		Calculated Values			
		hr/wk		% of Total		Cond. IV	Cond. V	Cond. IV		Cond. V	
Division	Rating	UT	A/S	UT	A/S	OUS, hr/wk	OUS, hr/wk	UT, hr/wk	A/S, hr/wk	UT, hr/wk	A/S, hr/wk
X	PO	0.0	50.0	0.0	100.0	45.40	0.0	0.0	45.40	0.00	0.00
X	MA	1/	--	0.0	100.0	45.40	0.0	0.0	45.40	0.00	0.00
X	PC	8.7	3.6	70.7	29.3	41.00	2.3	29.0	12.00	5.16	2.14
X	PN	12.0	38.0	24.0	76.0	142.00	43.90	34.08	107.92	10.52	33.36
X	YN	37.5	68.7	35.3	64.7	92.00	101.70	32.49	59.51	35.91	65.79
N	QM	21.4	46.6	31.5	68.5	67.00	55.60	21.09	45.91	17.50	38.10
H	HM	50.0	26.0	65.8	34.2	77.00	29.40	50.66	26.34	19.34	10.06
OC	RM	115.0	44.7	72.0	28.0	66.10	71.90	47.60	18.50	51.78	20.12
OC	SM	30.9	15.5	66.6	33.4	31.30	39.40	20.84	10.46	26.24	13.16
OE	ET	134.6	18.6	87.9	12.1	50.00	80.00	43.96	6.07	70.29	9.71
OI	EW	54.0	0.0	100.0	0.0	32.00	30.30	26.00	6.00 2/	24.30	6.00 2/
OI	OS	53.4	41.2	56.4	43.6	98.10	84.80	55.38	42.72	47.87	36.93
AD	SN	3/	--	100.0	0.0	35.00	0.00	35.00	0.00	35.00	0.00
D1	BM	136.4	42.5	76.2	23.8	322.91	290.30	246.20	76.71	221.34	68.96
D1	YN	5.0	41.0	10.9	89.1	41.00	0.00	4.46	36.54	0.00	0.00
D2	GMG	65.0	14.2	82.1	17.9	55.00	62.20	45.14	9.86	51.05	11.15
F	FTG	29.3	25.2	53.8	46.2	63.00	33.80	33.87	29.13	18.18	15.63
F1	FTM	4/	--	50.0	50.0	10.00	14.20	5.00	5.00	7.10	7.10
F2	GMT	1.0	1.9	34.5	65.5	22.00	10.50	7.59	14.41	3.62	6.88
F2	STG	106.6	17.8	85.7	14.3	130.97	95.90	112.23	18.74	82.18	13.72
F2	TM	20.0	7.0	74.1	25.9	25.00	13.30	18.52	6.48	9.85	3.45
A	EN	17.7	22.0	44.6	55.4	34.00	44.70	15.16	18.84	19.93	24.77
A	MM	33.0	17.0	66.0	34.0	50.00	98.80	33.00	17.00	65.21	33.59
A	MR	33.0	12.0	73.3	26.7	33.00	2.90	24.20	8.80	2.13	0.77
A	YN	11.0	36.0	23.4	76.6	40.92	0.00	9.58	31.34	0.00	0.00
B	BT	84.1	68.9	55.0	45.0	139.98	150.20	76.94	63.04	82.56	67.64
E	EM	66.7	34.4	66.0	34.0	91.13	62.80	60.12	31.01	41.43	21.37
E	IC	59.9	29.7	66.9	33.1	49.90	47.80	33.36	16.54	31.96	15.84
M	MM	187.1	35.3	84.1	15.9	62.00	166.10	52.16	9.84	139.74	26.36
R	HT	167.2	31.4	84.2	15.8	190.07	53.50	160.02	30.05	45.04	8.46
S1	SK	63.0	162.0	28.0	72.0	249.97	91.50	69.99	179.98	25.62	65.88
S2	MS	5/	--	15.0	85.0	718.97	314.40	107.85	611.12	47.16	267.24
S3	SH	218.0	47.0	82.3	17.0	228.00	114.00	187.56	40.44	93.78	20.22
S4	DK	6.1	43.9	12.2	87.8	88.10	41.00	10.75	77.35	5.00	36.00
S5	MS	5/	--	15.00	85.0	284.00	140.00	42.60	241.40	21.00	119.00

1/ No backup data; calculated based on X PO data.

2/ 6.00 hr/wk A/S assigned notwithstanding SMD backup data.

3/ No backup data; 100% assigned as UT.

4/ No backup data; 50% assigned as UT, 50% assigned as A/S.

5/ Backup data considered inaccurate (food preparation apparently treated as UT), calculated with estimated values as shown.

APPENDIX D
FACILITIES MAINTENANCE DEMONSTRATION STUDY

DEPARTMENT OF THE NAVY
NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
HEADQUARTERS
BETHESDA, MARYLAND 20084

ANNAPOLIS LABORATORY
ANNAPOLIS, MD 21402
CARDEROCK LABORATORY
BETHESDA, MD. 20084

IN REPLY REFER TO:
2784:MAS
3930

2 SEP 1976

From: Commander, David W. Taylor Naval Ship R&D Center
To: Chief of Naval Operations (OP983)
Via: Chief of Naval Material (MAT03)

Subj: Shipboard Manning and Automation Project, Facilities Maintenance Demonstration Study

Ref: (a) CNO ltr 983C/635969 of 11 May 1976
(b) DTNSRDC ltr 2784:MAS/3930 of 20 April 1976
(c) CHNAVMAT FIRST ENDORSEMENT 034/AR of 6 May 1976
(d) OPNAVINST 3960.10

Encl: (1) Fleet RDT&E Support Request, Mod I

1. Reference (a) assigned the T&E identification number K397 to the Shipboard Manning and Automation Project, Facilities Maintenance Demonstration Study. The requested support was included in the CNO Requirement List for first and second quarters. FY77

2 Due to administrative delays in contracting, the requirement for the support requested in references (b) and (c) has been delayed In accordance with paragraph (5) of enclosure (4) to reference (d), enclosure (1) is submitted with a new schedule of support requirements.

HHBrown

Copy to:
CNM (MAT034,035)
CINCLANTFLT
COMNAVSURFLANT
COMNAVSEASYSCOM (SEA 0322, PMS 399)
COMOPTEVFOR
CNETS (Code N54)

FLEET RDT&E SUPPORT REQUEST, MOD I
(T&E Identification #K397)

1. REQUIREMENTS

a. Short-Term Requirements

The support requirements for successful prosecution of this RDT&E effort is as follows:

Short Term Requirements	Type	Extent	Duration	Dates Start	End
1	FF-1052 (1)	Not-to Interfere (NIB)*	5 Months	1 Mar 77	1 Aug 77
2	LST-1179(1)	NIB	5 Months	1 Mar 77	1 Aug 77
3	FF-1052 (6)	NIB	20 Months	1 Nov 77	1 July 79
4	LST-1179 (1)	NIB	20 Months	1 Nov 77	1 July 79

The supporting units will not be required to meet any unusual training or operating requirements during this test and evaluation program. A training program will be administered to individuals aboard support units but the program is of the normal shipboard divisional training type and will not affect unit deployment requirements in any way.

b. Long-Term Requirements

It is requested that COMOPTEVFOR and COMNAVSURFLANT provide an independent evaluation of this project based on data provided by DTNSRDC via the Test Plan and their observation as they desire.

2. PURPOSE

a. The program for which the above support is requested is the Shipboard Manning and Automation Project, Facilities Maintenance Demonstration Study, David W. Taylor Naval Ship Research and Development Center (DTNSRDC), Code 2784, Annapolis, Maryland 21402. The program element number is 62757N. The project number is SF55525212.

b. The purpose of the program is to develop, test, and evaluate systems of innovations in facilities maintenance (FM) management, training, equipment and materials in terms of their ability to:

---

*Not-to-Interfere Basis means that the support being requested permits full employment of the supporting unit for normal missions without interference from the RDT&E effort.

Enclosure (1), Page 1

(1) reduce FM man-hour requirements/expenditures aboard ship.

(2) improve condition, cleanliness and appearance of ships.

(3) elevate skill/knowledge of personnel required to perform FM.

Facilities maintenance is defined as activities of ship's force personnel directed at surface preparations, corrosion control, preservation, housekeeping and janitorial services, (e.g., buffing, stripping, sweeping, washing, scrubbing, etc.) done to maintain an acceptable level of ship condition, cleanliness and appearance.

c. It is planned that the purpose of this RDT&E program will be achieved by implementing systems of FM innovations aboard operational Fleet units and evaluating the impact of these innovations in Fleet demonstration tests. Innovations to be evaluated will include:

(1) a newly developed management information system for FM task assignment and scheduling.

(2) a revision to current manpower organization concept for FM accomplished.

(3) a newly developed audio-visual FM training program.

(4) a variety of labor saving devices and materials.

Test measures will include:

(5) estimates of FM man-hour expenditures.

(6) rating scale evaluations of shipboard spaces.

(7) skill and knowledge test scores.

(8) Debriefing questionnaires.

During the earlier phases of this program (see short term requirement numbers 1 and 2 in Section 1. above), it is planned that the supporting units will be boarded by data collectors for the purpose of developing data for the information management system and for estimating FM man-hour expenditure and shipboard cleanliness, condition and appearance in the absence of any of the previously mentioned innovations. Data collection visits will be coordinated with cognizant shipboard authorities. Data collectors will measure spaces, describe surfaces, and determine FM task requirements with the aid of knowledgeable shipboard personnel or staff. Prior to any activity by the study staff or data collectors, the Commanding Officer and staff of the support units will receive orientation briefings concerning all aspects of this study program. For the remaining short term requirements (items 3 and 4 in Section 1), the following is the planned general approach to testing:

- Orientation briefings to support units setting forth the purposes, conditions, and support requirements for testing.

- Selection of participating ships force personnel for the newer manpower organization concepts.

- Selection of control subjects for testing.

- Administration of paper and pencil tests.

- Data collectors begin sampling of spaces for ratings of cleanliness, work time, etc.

- Installation of innovations.

- Periodic data collection on FM task times, etc.

- Intermediate and final questionnaires and test administration.

Data collectors, for each visit to supporting units, will conduct their tests after appropriate coordination with shipboard authorities.

d. There are no special conditions needed for tests. However, it would be desirable if supporting units are home ported in NORVA so as to minimize travel costs to the program.

e. The Test Plan will be available 1 Mar 1977.

3. DESCRIPTION AND STATUS OF EQUIPMENT

a. Equipment to be installed or taken aboard includes the following:

Equip. Item	Quantity/Ship	Pwr.Req.	Total Est. Wt.	Effects on Ship Performance
Pressure Washer	1 ea	120 VAC	250 lbs.	None
Wet Vacuum	2 ea	120 VAC	100 lbs.	None
Dry Vacuum	2 ea	120 VAC	100 lbs.	None
Walk-Off Mat	1,000 Sq.Ft.	-	1,000 lbs.(INST)	None
Deck Finish	25 Gal.	-	200 lbs.	None
Detergent & Chemicals	50 Gal.	-	400 lbs.	None
Floor Machines (17")	2 ea.	120 VAC	200 lbs.	None

Enclosure (1), Page 3

Equip. Item	Quantity/Ship	Pwr. Req.	Total Est. Wt.	Effects on Ship Performance
Carpet Shampooer	1 ea	120 VAC	60 lbs.	None
Misc. (swabs, pads, etc.)	-	-	500 lbs.	None
Airless Paint Cup Gun	6 ea	120 VAC	100 lbs.	None
Peening Devices (Surface Prep.)	6 ea	120 VAC	100 lbs.	None

b. Number of personnel required to operate and maintain the equipment aboard ships requested is 12-25. The personnel requirement aboard ship will not present additional workload demands since the operation and maintenance of this equipment is part of normal workload for FM personnel. There are no special qualifications required for personnel aboard ship since this RDT&E program provides training on a divisional training basis to personnel involved.

c. No shipyard or tender availability will be required for installation.

d. Estimate of installation time for all innovations is one month (on a not-to-interfere basis*)[1]. Estimate of removal time is one week. Ships force assistance may be required for installation/removal. Estimated ships force required for installation removal:

Type Personnel	Time
Ship Fitter	2 mandays
Electrician	2 mandays

*See footnote on page 1.

[1] The pressure washer is the only equipment to be installed in the ships. The balance of the equipment and software require no installation support.

FACILITIES

MAINTENANCE

David W. Taylor Naval Ship Research and Development Center

Code 2784

Tel. (301) 267-2764
AUTOVON 281-2764

FACILITIES MAINTENANCE

Facilities Maintenance aboard ships consumes a large portion of valuable material and manpower resources and is generally not performed efficiently. If technology is not applied to improve the way facilities maintenance is accomplished, it will consume greater and greater proportions of the manpower available to perform essential operations and maintenance actions. As new ships are tending to be designed to be operated by significantly fewer personnel, actions will have to be taken to reduce the amount of resources consumed by Facilities Maintenance.

Facilities Maintenance Defined

Facilities Maintenance (FM) is defined as those actions performed by ships force necessary to maintain the condition, cleanliness, and appearance of the exterior and interior of the hull and hull fittings including cleaning, preservation, surface preparation and painting.

Facilities Maintenance actions can be divided into several groups of tasks. These groups are housekeeping tasks, surface preparation and corrosion control tasks, cleaning of bilges, and vent and duct work cleaning tasks. Housekeeping tasks include such activities as scrubbing, polishing, vacuuming, dusting, sweeping, swabbing, etc. Surface preparation and corrosion control tasks include chipping, scraping, grinding, peeling, priming, painting, etc. Cleaning bilges involves removal of water and oily-water, various petroleum products, and small debris. Vent and duct cleaning tasks include the cleaning of filters as well as ducting.

Background

Research and development to reduce the number of men required to

perform FM efficiently was initiated as a joint Fleet/Navy Laboratory project in 1973. Since that time the first phase of research and development work has been completed. Plans are going forward to expand the research and development to provide a technology base from which Ship Acquisition Managers can draw to help ameliorate manning requirements. The David W. Taylor Naval Ship Research and Development Center (DTNSRDC) in conjunction with the Naval Personnel Research and Development Center (NPRDC) is conducting the R&D funded by exploratory development monies supplied by Chief of Naval Material Direct Laboratory Funds.

The Problems

The FM project was initiated in response to problems identified by the Fleet. These problems concerned the personnel assigned to FM duties, inadequacies in equipment, the lack of a systematic management approach, the fact that ships have not been designed for ease of FM, and that there are no objective standards for measuring the adequacy of FM. Men assigned FM duties are usually lower rated men who are neither adequately trained nor sufficiently motivated to do FM. Equipment used in FM aboard ship does not reflect the most recent technological advances in the civilian cleaning industry. There is no adequate system for keeping track of FM requirements and scheduling and assigning the work efficiently. New ships are now being designed with new coatings and sheathing materials, but these new materials require special attention to avoid damage to them. Older ships have to contend with the lack of these labor saving improvements. While most persons in a leadership and supervisory capacity use subjective criteria for judging FM effectiveness in a ship, there is a lack of objective, clearly defined standards.

Objective of the Total FM Project

The objective of the FM Project is to devise, demonstrate and evaluate methods of reducing shipboard FM man-hour expenditures while improving the condition, cleanliness and appearance of shipboard spaces. It is important in this project that whatever is conceptualized be demonstrated aboard ships in the Fleet today. This serves the dual purpose of verifying the development improvements in an actual environment and of gaining Fleet acceptance of the new concepts being employed. A shipboard evaluation also has the side benefit of demonstrating technology that can be applied to new ships and also demonstrating a prototype that can be easily adapted to backfit.

The specific goals in the FM Project are to decrease FM man-hour expenditures, improve the skill and knowledge of the personnel performing FM, provide a cleaner and better maintained ship, and improve the attitude and motivation of personnel assigned to FM duties.

First Phase Approach

Previous studies have been conducted to help solve FM problems. There have been studies done on an individual area such as labor saving devices, the psychological aspects of menial work, and new coatings and materials. But, none of the previous work in FM addressed the problems from a systems approach—there was no work done on finding the best mix and combination of innovations.

The first phase of the FM Project dealt with FM as a system comprised of leadership, training, equipment, organization and management. Concepts were generated for solving FM problems within the system structure and

fell into three categories: manpower organization and information management; training and technical support; and FM equipment, materials, and environmental improvements.

A variety of industrial and military sources were contacted and provided inputs to the project. These sources included professional maintenance organizations, appropriate Navy organizations, shipyards, and cleaning materials manufacturers. A large contribution was received from the British Ministry of Defense and Royal Navy in the form of an information management system which formed the basis of the information system in this project. All of the innovations and concepts received were carefully screened and then put together in a package for at sea demonstration.

The Demonstration

The FM System synthesized in the first phase of research was tested for six months in USS TRIPPE (FF-1075). Leadership involvement included significant command attention and a systematic evaluation of the effectiveness of the FM package by all levels in the chain of command. Training included a series of slide-tape modules and a collection of available technical documentation in FM. Testing was conducted to measure the effects of training. Equipments tested in TRIPPE included various labor saving devices, some environmental improvements, and cleaning chemicals. Organizational changes included task consolidation, and the use of a team comprised of eight men from the 1st division to do FM work in the division and all common use spaces on the ship. The management system included a scheduling system and Facilities Maintenance Requirement Card (FMRC) (Job Information Card of the Royal Navy), similar to Maintenance Requirements Cards in the preventative maintenance system. An example of a FMRC is

attached to this paper. A feedback method was included to inform the supervisor of problems in the various spaces that were beyond the scope of the FM personnel.

Training

Thirteen training modules were developed and evaluated in USS TRIPPE. These slide-tape modules are a series of 35mm slides with a script recorded on a cassette tape. The tape has cueing information included so that automatic changing can be accomplished if the project to be used is so equipped. Examples of the subjects for which modules were made are "Why We Clean," "Safety," "Routine Care of Tile and Terrazzo Decks," "Cleaning Heads," etc. The technical reference package included NAVSHIPS instructions, BUMED instructions, and manufacturer information booklets.

Equipment and Materials

The following is a list of equipment included in the demonstration of the FM Project:

Pressure Washer - an installed pump with a 2000 psi capability which can pump chemicals, chemicals and water, or water. Attached to this pump is a 200 ft. quick disconnect hose with a wand. The system is used for topside washdown.

Wet and Dry Vacuum Cleaners - While dry vacuum cleaners are usually included in a ship's equippage, more were placed on the TRIPPE in order to fully utilize their capabilities. Wet vacuum cleaners are used to remove deck stripping chemicals. (Can be used in any wet operation such as bilges.)

Wall Deterger - A device for cleaning bulkheads.

Square Buffing Machine - This machine vibrates instead of rotating. Since it is rectangular, it is useful on long expanses of passageways, especially in operation adjacent to the bulkheads.

Trash Compactor - This was used in the normal manner.

Carpet Shampooer - Used in carpetted spaces to remove carpet damaging grit and soil.

Pressure Sprayer - This hand held device is used to clean under the rings of toilets, urinals, and under sinks.

Deck Finishes - A metallized acrylic applied to the vinyl asbestos tile and terrazzo instead of wax.

Swabs, Buckets, Brooms, Squeegees - Normal equipment, but placed on the ship in sufficient quantities.

Walk Off Mats - These mats replace the standard coco mats and because of their design effectively trap soil and grit and prevent soiling clean areas.

Carpet - Nomex carpet was placed in the crew's lounge and one passageway for evaluation.

Results of TRIPPE Demonstration

- The time required to perform FM decreased 42%.
- The Skill and knowledge of FM personnel was significantly increased.

Limitations of Research to Date

The first phase of the research and development was limited in scope to avoid large expenditure of funds before some of the basic concepts were tested. Only forty percent of the spaces in TRIPPE were involved

and only the 1st Division supplied men to the FM team. Surface preparatio. and corrosion control were not included in this demonstration, nor was bilge cleaning or vent and duct cleaning. The next phase of the project will include these items.

Second Phase Approach

In the second phase of this research, the management system will be expanded, additional training will be developed to include the expanded FM system, new equipment will be added for the accomplishment of all FM tasks, and the expanded system will be evaluated on a whole-ship basis. In addition, mission related problems in the accomplishment of FM will be investigated.

Expanded Management System

The management system will be developed to include FM tasks for the entire ship. Facilities Maintenance Requirement Cards will reflect the proper procedures, equipment and materials. The FM tasks, specialized training, and responsibilities of the FM team, will be investigated. It could well be that a one-team concept will not be acceptable for a certain size ship and thus teams will have to be organized by departments or divisions. A technical manual will be developed to consist of three parts. One part will be an instructional guide on setting up an FM System. Another part will contain training information applicable to any ship. The last part will be the management system with specific F-MRC's for the test ships.

Expanded Training

The Chief of Naval Education and Training is being asked to provide

a continuous input to the development of the FM training package. In this way, consistency and professionalism in the final training modules can be ensured. The training package is being expanded to include surface preparation, painting, vent and duct cleaning, and bilge cleaning.

Equipment

Equipment for this phase will be selected based on the results of the first phase and the studies on labor saving devices by COMNAVAIRLANT. It was determined that such equipment as pressure washers and wet vacuum cleaners were useful; the wall deterger did not help much. Painting, chipping, and vent cleaning equipments will be added.

Entire Ships

This phase of FM is expected to include a demonstration on seven ships. Various combinations of the FM system will be placed on various ships of the same class and on one ship of another class. The demonstration is planned for six FF-1052 Class ships and one LST-1179 Class ship. It is felt that the problems in an LST, with its transient population, would closely resemble problems on large amphibious ships and carriers. A training package and management system can be provided the transients to assist in keeping the whole ship clean while saving them man-hours.

Intermediate Maintenance Activities

Any equipment placed on ship should be maintainable and reliable. In order to complement the training in each ship on the care of FM equipment, it is planned for an IMA to be provided with a rotatable pool of equipment. It is expected that the IMA will provide replacement equipment while they perform maintenance beyond the capabilities of ship's force.

Development Schedule

Plans are now in progress to complete this research and to make available to system acquisition managers as much finished work as possible. It is expected that a contract will be let in the summer of 1976 for all software development. Equipment will be bought and assembled and installed aboard test ships in the summer of 1977 and a one year evaluation will commence about October 1977. It is expected that a final report on this project will be available in March 1979.

Three Part Technical Manual

The technical manual developed as part of the software package will be in three parts. One part will be a guide to the development of the FM management system of any type ship including how to set up schedules, teams, and how to construct Facilities Maintenance Requirement Cards (F-MRC) for specific ships. Another part will be complementary to the training package and can be used on any type ship. The third part will be tailored to the specific management system on the test ships. The first two parts will be available, but untested, in July 1977.

Training Package

The training package will be applicable to any ship. Modules will be developed to teach the accomplishment of tasks and the use of specialized equipment. If certain types of FM equipments are to be placed on a particular ship, those specific training modules can be added to the general modules for use on any ship. The training package is expected to be available, but untested, in July 1977.

Equipment/Material/Environmental Improvement

A description of the equipment, material, and environmental improvement package to be used in the demonstration will be available in June 1977.

Technical Liaison

The Project Office of DTNSRDC, Code 2784, is available for consultation during the conduct of the research. Close liaison between the Project Office and acquisition managers can assist them in identifying and solving FM problems even while this final phase of research is being conducted. Results from Phase I can be useful now and concepts already developed can be transitioned into implementation.

GSA FPMR (41 CFR) 101-11.6
UNITED STATES GOVERNMENT
Memorandum

034/WTH

TO : MAT 0531 DATE: 10 November 1976

FROM : MAT 034B

SUBJECT: Manpower-Savings Initiatives

MAT 05 memo of 26 Oct 1976

1. Reference (a) requested nominations of candidate programs for inclusion in the report to Congress on this subject.

2. The following efforts are currently underway in the 6.2 (Exploratory Development) area that are nominated:

<u>P. E.</u>		<u>Contact</u>
62757N	Training and Human Engineering Technology	MAT 0344, x22144
	<u>Integrated Bridge System</u> - To demonstrate the feasibility of an Integrated Bridge System concept for achieving shipboard manning reduction while maintaining or improving ship readiness and operational effectiveness.	
	<u>Facilities Maintenance</u> - To demonstrate a reduction in Facilities Maintenance man-hour requirements while improving conditions, cleanliness and appearance of shipboard spaces.	
62761N	Materials Technology	MAT 0342, x22144
	<u>Several Welding Technology Projects</u> - To demonstrate new welding systems and techniques to increase productivity resulting in large reductions in requirements for material and labor in the fabrication/repair of Navy ships.	

Respectfully,

W. T. Hildebrand
CDR, USN

Block Program Plan for
Shipboard Manning and Automation Program
Program Element 72757N
Project SF5552521B

1. Operational Requirements. CNO Action Sheet 303 of May 1972 emphasized the need for manning reduction and OP-37 has drafted an Operational Requirement addressing shipboard manning and automation which is currently in review. Scientific and Technological Objectives for Support, Logistics, and Underway Replenishment (STO-SL) of April 1975 states that, "a reduction in shipboard manning of 25% is considered a minimum objective, and 75% a long-term goal."

2. Background. This program was established as a Direct Laboratory Funded (DLF) Program under the Chief of Naval Material (MAT 03) and is being transitioned to a Block Program in the Naval Sea Systems Command (SEA 03). In response to the CNO Action Sheet 303 the purpose of this program is to demonstrate the means for achieving reduction in shipboard manning with maintained or improved ship readiness and operational effectiveness.

3. Objective/Sub-Objective.

a. Bridge - Demonstrate that the bridge watch functions on frigate/destroyer type ships can be performed as effectively or better with about one third the watchstanders using an integrated bridge system as compared to traditional bridge designs and watchstanders.

b. Facilities Maintenance - Demonstrate that implementation of an innovative facilities maintenance system can result in a cleaner, better maintained ship with about thirty percent less manhours.

4. Approach.

a. Bridge. Those functions which are required to be performed on the bridge were identified in the CNO Pilot Program for Reduced Bridge Manning. An extensive survey was conducted using inputs from the U.S., Canadian, and British Navies to identify the kinds and priorities of information required on the bridge to perform those functions. A state-of-the-art survey was conducted in industry and merchant marines both foreign and domestic. Certain equipments were evaluated on U.S. Navy ships. A human engineered mock-up was developed and reviewed by the Fleet. Specifications for an Integrated Bridge System (IBS) were developed and a contract was awarded for the procurement of the IBS. OPNAV tasked COMOPTEVFOR to provide an Operational Assist in evaluating the system aboard an FF-1052 Class ship.

b. Facilities Maintenance (FM). FM is defined as those actions performed by ship's force necessary to maintain the condition, cleanliness and appearance of the exterior and interior of the hull and hull fittings including cleaning,preservation, surface preparation, and painting.

a survey was conducted to determine how FM was being performed in the U.S. Navy, British Navy, and industry. It was decided that for the first shipboard demonstration that a system would be developed to address only cleaning and limit the coverage to about thirty five percent of the ship.

The first demonstration system was installed on USS TRIPPE (FF-1075) and included: (1) provisions for giving FM command attention, (2) an audio/video training program, (3) state-of-the-art equipment and materials, and (4) an organization and management system for efficient scheduling and performing FM.

Based upon the success of the demonstration on USS TRIPPE, the concept will be expanded to include the total ship and also include bilge cleaning, surface preparation and corrosion control. The second concept demonstration will provide for modifications in the training program, equipment/materials package, and organization and management system. The modifications will be made to take advantage of lessons learned on USS TRIPPE and also to tailor each demonstration package to the three classes of ships on which demonstrations are to occur. The concept will be demonstrated on FF-1052, LST-1179, and FFG-7 classes of ships. Additionally, documents will be developed as guides for developing FM Technical Manuals, Facilities Maintenance Requirements Cards (FMRC), and Facilities Maintenance Management Systems.

5. Milestones and Funding Schedule. See attached sheet.

6. Priorities. First priority is the Integrated Bridge System (IBS). Current guidance from CNM (MAT03) is that the IBS will be funded at the expense of delaying the facilities maintenance (FM) work if there are any funding deferrals. A contingency plan should there be a funding deferral in FY77 is to delay the FM hardware procurement and stretch out the FM software contract work to be completed later in FY78. That would delay the evaluation and associated costs to FY79. Any delay in the FM program would be undesirable, however, because of the expected input to the FFG-7 Class ships FM organization, procedures, equipments, and training.

a. Monthly reports will be made to DTNSRDC management. Semi-annual program reviews will be presented to NAVSEA and NAVMAT in December and June. Semi-annual progress reports and an annual report will be submitted as spelled out in paragraph (11). The plan will be updated annually.

b. The program is divided into the two parts, bridge and facilities maintenance, identified in the objective and approach. The efforts will be under the overall management of the Program Manager (GS-14) and Project Officer (CDR, USN).

(1) The bridge effort manpower requirements include a Project Coordinator (GS-12/13) of DTNSRDC, Test Director (GS-13) of DTNSRDC, Research/Test Analyst (GS-12/13) of NPRDC, Senior Project Engineer (GS-13/14) of NADC, and contractor support. Technology transition has been and will be made to the Surface Ship Bridge Control System, NAVSEC and the various SHAPMS of new construction ships.

(2) The facilities maintenance effort manpower requirements include the Project Coordinator (GS-13) of NPRDC, Project Engineer (GS-12/13) of DTNSRDC, review assistance from CNET and NAVSEC, and contractor support. Technology transition has been and will be made to NAVSEC and the various SHAPMS of new construction ships.

9. Block Principal. Mr. L.F. Marcous of DTNSRDC (Code 27).

10. References.

a. Naval Engineers Journal, "Design of an Integrated Bridge," L. Puckett, R.H. Gowen, and G.L. Moe, April 1975.

b. Proceedings, Fourth Ship Control Symposium, "Integrated Bridge Systems," J. Dachos, W. Behan, and B.V. Tiblin, October 1975.

c. Commander, Navy Personnel Research and Development Center Report, "Shipboard Facilities Maintenance and Manpower Utilization: Problem and Approach," M. Schwartz, Report TR-7622.

d. DTNSRDC Report PAS 75-47, "Shipboard Manning and Automation Program," P. Edmondo, July 1975.

e. NSRDC Report 27-734,"Deck Log and Quartermaster's Notebook Investigation as a Part of the CNO Pilot Program for Reduced Bridge Manning," April 1974.

f. NSRDC Report 27-742, "CNO Pilot Program for Reduced Bridge Manning, Manpower/Equipment Integration and Procedural Development," April 1974.

g. NSRDC Report 27-756, "Reduced Bridge Manning Without Equipment Augmentation - Results of Ship Reports and Comments," April 1974.

h. NSRDC Report 4281, "CNO Pilot Program for Reduced Bridge Manning - Equipment Report," May 1974.

i. NSRDC Report PAS 74-29, "Shipboard Manning and Automation Program Annual Report, Fiscal Year 1974," July 1974.

j. Human Factors Research, Inc., Report 1745, "Design of an Integrated Bridge Intended to Reduce Bridge Manning on Navy Ships."

k. Proceedings of the Institute of Navigation, "Report on Operational Demonstration of Automatic Navigation to Reduce Bridge Manning," J. Dachos and D. Chaney, October 1974.

l. NSRDC Report 27-640, "Annual Report on Shipboard Manning and Automation Project," July 1973.

m. COMDESDEVGRU Technical Report 17-73, "Findings of the Pilot Program for the CNO Shipboard Automation and Manpower Reduction Project," September 1973.

n. COMDESDEVGRUTWO Report on Facilities Maintenance Concept Evaluation on USS TRIPPE (FF-1075). In preparation.

o. NPRDC Report TR 76-29, "Facilities Maintenance Demonstration Study," January 1976.

11. Reports. The DTNSRDC Technical Directorate will review the block plans semi-annually in May and November. The program will be reviewed with the sponsor/program manager in June and December. The plan will be documented and forwarded to the sponsor in March and September in the format of this submittal.

MILESTONE A

PROJECT NO. SF55-525

BLOCK NO. ________ TITLE Shipboard Manning and Au

SEGMENT NO. ________ TITLE ________

WORK PHASE	75	76	7T	77	78	79	8
	APPROX. TIME MILESTONE IS REACHED (FY)						
1. Integrated Bridge System (IBS)							
• Design and Fabricate System							
• Prepare for At-Sea Evaluation			R				
• Install and Checkout System					R		
• At-Sea Evaluation							
• Remove IBS and Restore Ship							
2. Facilities Maintenance (FM)							
• Phase I Shipboard Evaluation		R					
• Develop Phase II Plan				R			
• Prepare RFP for Software							
• Develop Software (Mgmt.Supt., FMRC's, Trng.Pkg.)							
• Develop Hardware Specifications							
• Contract for Hardware							
• Develop Shipboard Evaluation Plan							
• Install FM System Aboard Ships						R	
• Shipboard Evaluation							
• Restore Ships							

△ START Ø COMPLETED * INTERMEDIATE

O MAJOR MILESTONE Ø.....O TIME SLIP R REPORT

APPENDIX E
NOTIONAL WORK PACKAGES

E.1 The FF-1052 class was designated as the first class of ships to enter the Destroyer Engineered Operating Cycle (DDEOC) Program. The objectives of this program are to effect an early improvement in the material condition of designated ships and maintain the ships in a material condition ready for war at an acceptable cost, while maintaining or increasing their current peacetime operational availability. Similarly, the Class Maintenance Doctrine for the guided missile frigate (FFG-7) is based on the objectives of minimizing shipboard manning for maintenance (as part of the effort to minimize the total required shipboard manning) and increasing at-sea utilization of the ship.

E.2 The maintenance strategy for these classes is similar in that designated periods of intense maintenance activity are planned to increase the time between overhauls. These periods will consist of both intermediate maintenance availabilities (IMAVs) at intermediate maintenance activities (IMAs) and selected restricted availabilities (SRAs) at depots. During these maintenance periods, specified tasks will be accomplished by both ship's force and IMA/depot personnel. The tasks to be accomplished during each maintenance period will be specified in a work package prepared as part of the maintenance strategy for each class. The work packages will, among other things, list the tasks to be accomplished, identify the activity (ship and/or IMA/depot) that will accomplish each task, and estimate the effort (in hours and/or man-hours) required to accomplish each task.

E.3 Work packages for each class currently are being developed. Thus far, interim/draft work packages for both the FF-1052 [1/] and FFG-7 [2/] classes have been constructed. These packages are being revised and, in fact, are expected to be further modified as additional experience is gained with each class.

DEVELOPMENT OF NOTIONAL WORK PACKAGES

E.4 As part of the effort to evaluate the impact of alternative organizations on the organic maintenance capability of ships in the FF-1052 and FFG-7 classes, an alternative was constructed that centered on the concept of work packages. Since final/approved work packages have not been developed and since certain data manipulation was required to use the interim/draft work packages in conjunction with the ship work load (SWL) algorithm, notional work packages were developed for each class. [3/]

Procedure

E.5 The following steps were followed in developing the notional work package for each class:

a. Using the interim/draft packages as a source, tasks to be accomplished during each maintenance period (TAV or SRA for the FF-1052 class, IMAV or SRA for the FFG-7 class) by ship's force

1/ ARINC Research Corporation, FF-1052 Class Destroyer Engineered Operating Cycle (DDEOC) Maintenance Plan, July 1976.

2/ Automation Industries, Incorporated, Vitro Laboratories Division, Guided Missile Frigate (FFG-7) Class IMTMAV/SHARP Work Package, Revision 1, October 1975.

3/ The work packages are notional in the sense that they are based on unofficial interim products (and, hence, are subject to change) and are described in terms amenable to use with the SWL algorithm.

personnel were identified. In most cases, the task statements included sufficient detail to allow the specific work center(s) associated with each task to be identified. In some cases, however, the work center(s) to which the task would be assigned was not readily identifiable. For example, fire watches and fueling/defueling were assigned by the original work packages to the ship in general. In such cases, the tasks were prorated among work centers normally associated with such tasks (e.g., MMs, BTs and HTs for fueling/defueling) or among all work centers (e.g., fire watches).

b. Having identified the tasks to be accomplished by each work center for each maintenance period, each task was further categorized into an appropriate work category: PM, CM, or OUS (specifically UT). The bulk of the tasks were classified as either PM or UT; however, certain tasks, such as those described as "test and repair," were classified as incorporating both PM and CM.

c. Using the levels of effort specified in the original work packages, the required hours per week were identified for accomplishment of each task. Where a task resulted in PM <u>and</u> CM work load (such as "test and repair") the hours per week of PM and hours per week of CM were determined using the PM:CM ratios normally associated with the type of work described by the task. For example, if a "test and repair" task was assigned to an ET work center and the total

effort specified for the task translated into 8 hr/wk, the task would be considered to consist of 4 hr/wk PM and 4 hr/wk CM, based on the 1:1 PM:CM rates normally associated with ET work.

d. The hours per week of PM, CM and UT associated with each work center were computed for each maintenance period prescribed in the work package by summing the values for each task assigned to the work center.

e. Each task was then reviewed in an attempt to determine whether or not the task was originally included in the PMS system. In some instances, the task descriptions included reference to the PMS documents (e.g., Maintenance Index Page (MIP)) from which the work requirement arose. In other instances, a review of the PMS List of Effective Pages (LOEPs), MIP to Work Center File listing and individual MIP pages were used to establish the fact that the task was originally included in the PMS system.

f. The bulk of the PM (and, hence, a corresponding amount of CM) was determined to originate from PMS requirements previously assigned to each work center in the baseline development process on an average hours-per-week basis. Accordingly, a reduction in the average hours per week of PM and CM equivalent to the amount of PMS-associated PM and CM present in the work package was made for each work center.

g. The work-package UT work load (fire watches and fueling/defueling) was considered to exceed the

UT normally assigned to each work center; therefore, no reduction was made in the baseline average hours per week of OUS.

h. The PM and CM that could not be linked to the PMS requirements were treated as new work, and no reduction in the baseline average hours per week of PM and CM was made to compensate for such tasks.

i. The interim/draft work packages specified that certain tasks, such as vent cleaning for the FF-1052 class, had to be accomplished with a specified periodicity but not necessarily during one of the intense maintenance periods. In the case of vent cleaning, the hours associated with the task greatly exceeded the PMS-specified hours. Accordingly, the additional hours were treated as new PM work load, prorated among all work centers normally required to perform vent cleaning, and spread evenly over the time frame set by the periodicity (6 months). The result was an increase over the baseline average hours per week of PM assigned to certain work centers. In some cases, the increase due to additional vent-cleaning requirements more than offset the reduction made to account for PMS-related work-package PM.

Results

E.6 Tables E.1 and E.2 summarize the notional work packages for the FF-1052 and FFG-7 classes. The work centers identified are based on the formal organization described in the SMDs used

to develop the class baseline. The total hours per week of PM, CM and UT required to be accomplished due to the work package for each maintenance period are shown for each work center, as are the changes in the baseline work loads (average hours per week) required to compensate for the concentration of maintenance into specified periods.

TABLE E.1

FF-1052 CLASS NOTIONAL WORK PACKAGE SUMMARY

Work Center		Baseline Change, hr/wk	Work Package Demands, hr/wk												
			Maintenance Period and Schedule Weeks*												
Division	Rating		TAV-2 28-30	TAV-4 56-58	TAV-5 74-76	SRA-1 77-82	TAV-7 110-112	TAV-8 125-127	TAV-9 140-142	TAV-10 155-157	SRA-2 158-163	TAV-12 191-193	TAV-13 206-208	TAV-14 221-223	TAV-15 230-232
N	QM	PM: +0.54	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	5.60	--	--	--	--	5.60	--	--	--	--
OC	RM	PM: +2.00	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	101.10	--	--	--	--	101.10	--	--	--	--
OC	SM	PM	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	39.20	--	--	--	--	39.20	--	--	--	--
OE	ET	PM: -1.03	18.67	18.67	--	31.33	18.67	--	18.67	--	52.33	18.67	--	18.67	--
		CM: -3.03	18.67	18.67	--	20.67	18.67	--	18.67	--	41.67	18.67	--	18.67	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
OI	EW	PM	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	38.70	--	--	--	--	38.70	--	--	--	--
OI	OS	PM: +2.00	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	224.90	--	--	--	--	224.90	--	--	--	--
D1	BM	PM: +3.60	--	--	--	53.33	--	--	--	--	53.33	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
D2	GMG	PM: +3.60	--	--	--	--	--	--	--	2.67	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	5.60	--	--	--	--	5.60	--	--	--	--
F	FTG	PM: +2.57	--	--	--	17.78	--	--	--	--	33.28	--	--	--	--
		CM: -0.51	--	--	--	8.87	--	--	--	--	11.11	--	--	--	--
		UT	--	--	--	8.40	--	--	--	--	8.40	--	--	--	--
F1	FTM	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	67.20	--	--	--	--	67.20	--	--	--	--
F2	GMT	PM: +1.20	--	--	--	6.00	--	--	--	--	19.33	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	39.70	--	--	--	--	39.70	--	--	--	--
F2	STG	PM: +0.67	--	--	--	0.45	--	--	--	--	20.33	--	--	--	--
		CM: -0.27	--	--	--	0.22	--	--	--	--	10.33	--	--	--	--
		UT	--	--	--	109.60	--	--	--	--	109.60	--	--	--	--
F2	TM	PM: +1.20	--	--	--	5.33	--	--	--	--	5.33	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
A	EN	PM: +1.78	--	--	5.33	--	--	--	--	5.33	--	--	1.33	--	--
		CM: -0.01	--	--	--	--	--	--	--	--	--	--	0.33	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
A	MM	PM: -0.66	13.33	16.51	32.00	35.83	15.85	--	14.00	21.45	35.83	13.33	10.49	13.67	66.67
		CM: -1.00	6.67	7.75	--	7.50	7.75	--	6.67	1.09	7.50	6.67	4.91	6.67	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE E.1 (Cont)

Work Center		Baseline Change, hr/wk	Work Package Demands, hr/wk												
			Maintenance Period and Schedule Weeks*												
Division	Rating		TAV-2 28-30	TAV-4 56-58	TAV-5 74-76	SRA-1 77-82	TAV-7 110-112	TAV-8 125-127	TAV-9 140-142	TAV-10 155-157	SRA-2 158-163	TAV-12 191-193	TAV-13 206-209	TAV-14 221-223	TAV-15 230-232
B	BT	PM: -1.51	--	6.67	96.00	23.17	6.67	9.00	--	116.27	23.17	--	279.67	10.42	426.67
		CM: -0.21	--	--	--	4.16	--	--	--	--	4.16	--	--	--	--
		UT	--	--	--	22.57	--	--	--	--	22.57	--	--	--	--
E	EM	PM: -1.80	5.33	5.33	--	38.67	5.33	--	5.33	--	38.67	5.33	7.33	5.33	--
		CM: -0.85	--	--	--	16.67	--	--	--	--	16.67	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
E	IC	PM: -1.54	--	--	--	23.00	--	--	--	--	39.67	--	--	--	--
		CM: -0.38	--	--	--	3.33	--	--	--	--	11.67	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
M	MM	PM: -0.38	6.67	0.36	65.67	25.00	0.36	--	6.67	199.03	25.00	--	181.10	18.42	202.33
		CM: -0.42	--	--	--	8.33	--	--	--	--	8.33	--	--	--	--
		UT	--	--	--	0.95	--	--	--	--	0.95	--	--	--	--
R	HT	PM: +2.48	--	21.67	--	--	13.67	--	8.00	22.56	--	--	21.67	--	--
		CM: -0.06	--	--	--	--	--	--	--	2.22	--	--	--	--	--
		UT	--	--	--	3.40	--	--	--	--	3.40	--	--	--	--
H	HM	PM: +0.50	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
X	PC	PM: +0.50	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
S1	SK	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
S2	MS	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
S3	SH	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
S4	DK	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--
S5	MS	PM: +3.60	--	--	--	--	--	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--	--	--	--	--	--

* The notional work-package maintenance demand for all work centers for TAVs 1, 3, 6, and 11 is zero. These TAVs are omitted from the table.

TABLE E.2
FFG-7 CLASS NOTIONAL WORK PACKAGE SUMMARY

Work Center*		Baseline Change, hr/wk	Work Package Demands, hr/wk							
			Maintenance Period and Schedule Weeks							
Division	Rating		IMAV-1 27-29	IMAV-2 56-58	IMAV-3 85-87	IMAV-4 143-145	IMAV-5 172-174	IMAV-6 202-204	SRA-1 112-115	SRA-2 231-234
SC1	QM	PM	--	--	--	--	--	1.67	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	--	--
SC1	SM	PM	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	14.70	14.70
SC2	BM	PM: -4.09	31.07	48.69	31.07	31.07	48.69	48.69	30.52	23.31
		CM: -1.79	13.14	21.54	13.14	13.14	21.54	21.54	16.26	9.80
		UT	--	--	--	--	--	--	12.60	12.60
SC3	BM	PM: -8.14	53.67	79.02	87.11	53.67	130.51	53.67	90.54	94.39
		CM: -4.07	26.83	39.51	43.56	26.83	65.26	26.83	32.32	34.24
		UT	--	--	--	--	--	--	23.10	23.10
CS1	OS	PM: -0.01	--	0.12	--	--	0.12	--	0.09	0.09
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	12.10	12.60
CS1	EW	PM: -0.04	0.35	0.47	0.35	0.35	0.47	0.35	0.35	0.35
		CM: -0.04	0.35	0.47	0.35	0.35	0.47	0.35	0.35	0.35
		UT	--	--	--	--	--	--	2.10	2.10
CS2	ST	PM: -0.37	1.53	5.76	1.53	1.53	5.76	1.53	4.32	4.32
		CM: -0.20	0.93	2.68	0.93	0.93	2.68	0.93	2.16	2.16
		UT	--	--	--	--	--	--	6.30	6.30
CS2	TM	PM: -0.45	2.33	6.13	2.33	2.33	6.13	2.33	4.60	4.60
		CM: -0.19	1.17	2.57	1.17	1.17	2.57	1.17	1.93	1.93
		UT	--	--	--	--	--	--	--	--
CS3	FT	PM	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	8.40	8.40
CS3	GMM	PM: -1.81	12.75	22.55	12.75	12.75	22.55	12.75	16.91	16.91
		CM: -0.91	6.38	11.28	6.38	6.38	11.28	6.38	6.46	6.46
		UT	--	--	--	--	--	--	--	--
CS3	GMG	PM: -0.16	--	1.24	--	--	1.24	--	20.42	20.42
		CM: -0.08	--	0.62	--	--	0.62	--	1.82	1.82
		UT	--	--	--	--	--	--	4.20	4.20
CS4	ET	PM: -2.32	20.18	25.08	20.18	20.18	25.08	20.18	18.81	18.81
		CM: -2.85	24.97	30.68	24.97	24.97	30.68	25.78	23.31	23.31
		UT	--	--	--	--	--	--	4.20	4.20
CS4	DS	PM: -0.04	0.23	0.58	0.23	0.23	0.58	0.23	0.44	0.44
		CM: -0.04	0.23	0.47	0.23	0.23	0.47	0.23	0.35	0.35
		UT	--	--	--	--	--	--	--	--
CS4	IC	PM: -3.39	38.82	82.37	38.82	38.82	82.37	56.97	61.69	61.69
		CM: -1.69	11.28	21.70	11.28	11.28	21.70	11.36	16.31	16.31
		UT	--	--	--	--	--	--	2.10	2.10
E1	EN	PM: -3.15	69.93	75.52	66.50	66.50	77.39	80.19	73.74	63.64
		CM: -1.57	12.13	16.64	12.13	12.13	16.64	16.41	14.94	12.48
		UT	--	--	--	--	--	--	4.20	4.20
E1	EM	PM: -0.22	2.18	2.18	2.18	2.18	2.18	2.18	1.64	1.64
		CM: -0.11	1.09	1.09	1.09	1.09	1.09	1.09	0.82	0.82
		UT	--	--	--	--	--	--	4.20	4.20
E2	MR	PM: -3.57	25.68	12.82	33.30	25.99	47.14	26.30	30.60	30.34
		CM: -1.78	38.43	19.21	16.63	12.98	23.56	13.13	15.40	15.17
		UT	--	--	--	--	--	--	--	--
E2	EN	PM: -8.89	73.28	113.13	80.90	73.28	113.59	159.06	193.81	128.65
		CM: -4.39	26.82	46.71	30.63	26.82	43.27	51.01	51.11	35.05
		UT	--	--	--	--	--	--	10.50	10.50
E2	EM	PM: -10.63	162.25	176.01	124.92	37.18	226.49	124.92	176.99	111.18
		CM: -5.31	58.56	53.43	58.72	14.85	77.78	56.56	58.39	25.49
		UT	--	--	--	--	--	--	10.50	10.50
E2	MT	PM: -1.34	18.20	10.56	19.13	19.13	11.67	58.96	37.80	7.82
		CM: -0.67	8.17	4.35	8.63	8.63	4.90	8.71	3.27	3.21
		UT	--	--	--	--	--	--	4.20	4.20
S1	YN	PM	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	2.10	2.10
S1	SK	PM	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	2.10	2.10
S2	MS	PM	28.00	28.00	28.00	28.00	28.00	28.00	21.00	21.00
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	21.00	21.00
S2	SH	PM	--	--	--	--	--	--	--	--
		CM	--	--	--	--	--	--	--	--
		UT	--	--	--	--	--	--	8.40	8.40

* Work Centers S1 MA, S1 PN, S1 DK and S1 HM have no demands arising from the work package and, hence, are omitted from the table.

APPENDIX F
METHODOLOGY FOR CATEGORIZING DEFERRED WORK

INTRODUCTION

F.1 Both explicit and implicit in the various objectives of this study was the need to develop and present results that are more discrete than the outputs of the simulation model used in this analysis. For example, while interest was focused on the accomplishment of maintenance work loads, the ship work load (SWL) algorithm identified only total work deferral. Accordingly, the methodology presented in this appendix was developed to disaggregate rationally the total work-load deferral values into more discrete and useful statistics.

BACKGROUND AND PROBLEM

F.2 The SWL algorithm was designed to compute the total work load and capability for each work center on a ship and display the results in a manner that would allow imbalances to be recognized. Simply stated, the algorithm computes work load and capability, determines the difference between the two and outputs the results as either deferred work or slack (undertasking), depending on the nature of the imbalances. Although the inputs to the algorithm are categorized as to type of work (PM, CM, etc.), the deferral displayed as output cannot be converted directly back to specific categories unless certain assumptions are made with regard to the priority/sequence in which work is accomplished. The problem, then, is to specify the relative

priorities of the various work-load categories and, utilizing the SWL algorithm output, estimate the amount of work deferred in each work category for each work center.

SOLUTION

F.3 Since no known comprehensive work accomplishment priority scheme exists, it has been necessary to develop a notional work priority scheme to categorize deferral. The origination of the scheme is best stated in terms of the assumptions made during the development process. These assumptions are the following:

- All operational manning requirements are expected to be met as long as the total capability of the work center is sufficient to meet the requirements.
- Corrective maintenance may be treated as having three components with the following differing priorities attached to each.
  - CM associated with critical equipment--representing an estimated 30% of total CM, this component is expected to reflect a priority second only to operational manning.
  - CM associated with standby equipment--representing approximately 30% of the total CM, this component is expected to be accomplished on a midlevel priority basis.
  - Other CM--representing approximately 40% of the total CM, this CM is expected to be given a lower relative priority by the work center.

- Utility tasks/supply support (herein referred to as UT) may be viewed as having the following three components.
  - UT component associated either with short-term ship mission-essential work (such as fueling, rearming) or with the primary function of a work center (such as is the case with much of the UT work performed by SKs, DKs, etc.), this is estimated at 45% of the total UT and will be given a relatively high priority for accomplishment.
  - UT component associated with ship support tasks (such as UNREP stores) or with secondary functions of a work center, this represents approximately 45% of the total UT and is expected to be given a midlevel priority by the work center.
  - Other UT represents approximately 10% of the total UT and is expected to be accomplished on a low-priority basis.
- Preventive maintenance may be viewed as having the following two components.
  - PM associated with critical equipment and "high visibility" PM (e.g., PM affecting more than one work center), this component is estimated to represent 45% of the total PM and is expected to be given a midlevel priority by the work center.
  - Other PM, representing an estimated 55% of total PM, is expected to be accomplished on a priority basis that is somewhat lower than the critical equipment PM.

- Facilities maintenance may be treated in the following two parts.
  - FM performed in conjunction with health or sanitary efforts or in readily accessible/observable areas (e.g., living and messing spaces, officers' country, quarterdeck area, etc.) is estimated to represent 50% of the total FM and is perceived to be accomplished on a relatively high-priority basis.
  - Other FM, representing 50% of the total, is accomplished on a relatively low-priority basis.
- Administrative support/command support (A/S) may be viewed in the following three parts.
  - A/S directly associated with other categories of work and representing an estimated 21% of the total A/S carries the same relative priority as the associated work category component.
  - A/S associated with time-bound and/or mandatory reports, correspondence, etc., represents an estimated 20% of all A/S and carries a relatively high priority.
  - Other A/S, comprising approximately 59% of the total A/S, is expected to be given a relatively low priority.
- All deferral is unaccomplished work. Detractors (leave, training, etc.) are not deferred.

Work Priority Scheme

F.4 Based on the above assumptions, Table F.1 represents the theoretical order in which a work center might accomplish the work assigned if each work-load component were to be completed prior to starting on the next lower ordered component. This sequence is graphically represented Figure F.1. It would be assumed that work accomplishment would occur as follows: 100% of operational manning performed, then 30% of CM accomplished, then 45% of UT finished, etc.

TABLE F.1

NOTIONAL SEQUENCE OF WORK CATEGORY COMPONENT ACCOMPLISHMENT

	Category (Component)	Percent of Category
a.	OPMAN (all)*	100
b.	CM (critical equip.)	30
c.	UT (fueling, primary)	45
d.	A/S (assoc. with b and c)	3
e.	A/S (time bound/mandatory)	20
f.	FM (living, messing, etc.)	50
g.	A/S (assoc. with f)	3
h.	CM (standby equip.)	30
i.	UT (UNREPs, secondary)	45
j.	PM (critical equip./high visibility)	45
k.	A/S (assoc. with h, i and j)	15
l.	CM (remaining)	40
m.	PM (remaining)	55
n.	FM (remaining)	50
o.	UT (remaining)	10
p.	A/S (remaining)**	59

* Accomplished first.

** Accomplished last.

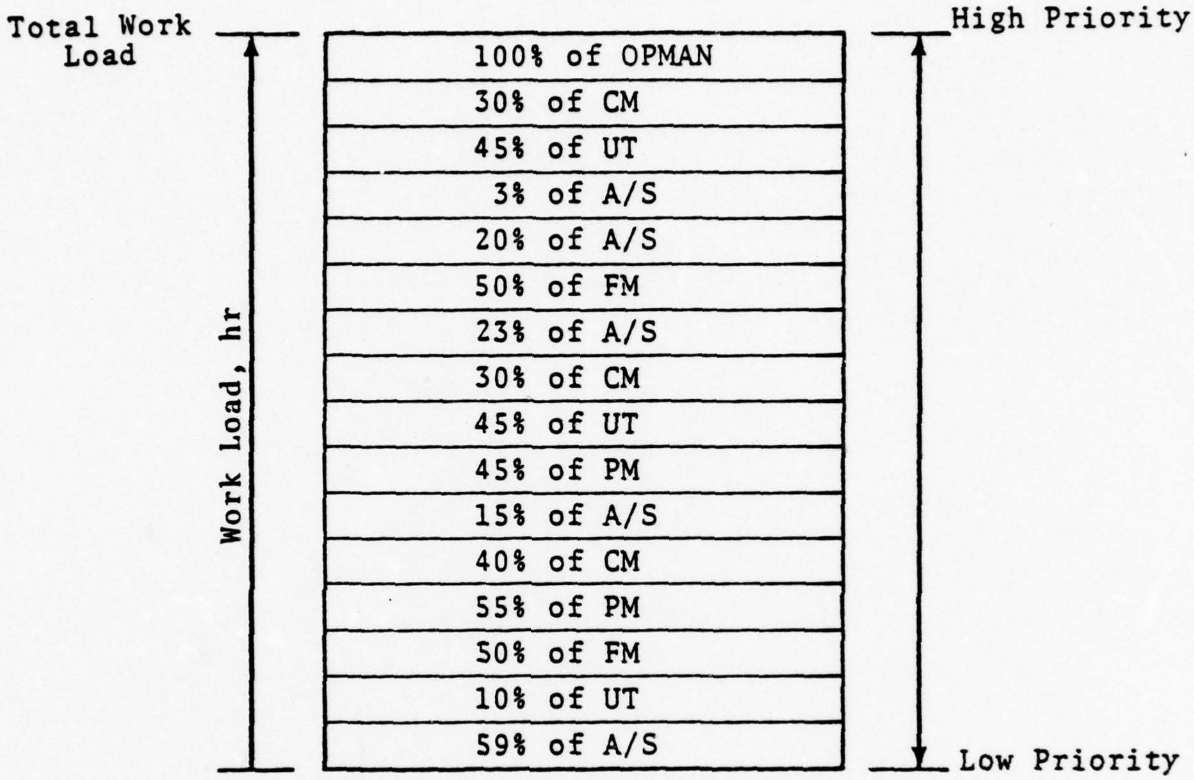

FIGURE F.1

NOTIONAL WORK PRIORITY SCHEME BASED ON SEQUENTIAL WORK ACCOMPLISHMENT

F.5 In reality, with the possible exception of single-man work centers, a number of activities will be accomplished nearly simultaneously by a work center. In addition, some aggregation of the categories and components is desirable to eliminate reliance on what may potentially be an overly specific priority ordering of the work-category components.

F.6 Figure F.2 shows an aggregated priority scheme in which work categories and components are grouped into five classes. The work-load composition of each class is as shown. For example:

Class D work load = 30% of CM + 45% of PM + 45% of UT
+ 15% of A/S.

Work accomplishment is treated as follows:

a. All Class A work accomplished on a first-priority basis

b. Class A and B work accomplished before Class C, D, or E work

c. Class A, B and C work accomplished before Class D or E work, etc.

F.7 The scheme shown in Figure F.2 will be used to break down work-center deferral into the various work categories. Note that, although the following paragraphs refer to this notional scheme, the application methods and techniques hold for any similar scheme. For example, if it was felt that all or part of the 45% of the UT shown in Class D actually should be given a higher priority (perhaps placed in Class C), the scheme can be easily modified to reflect the change, and the application process will readily produce results based on the modification.

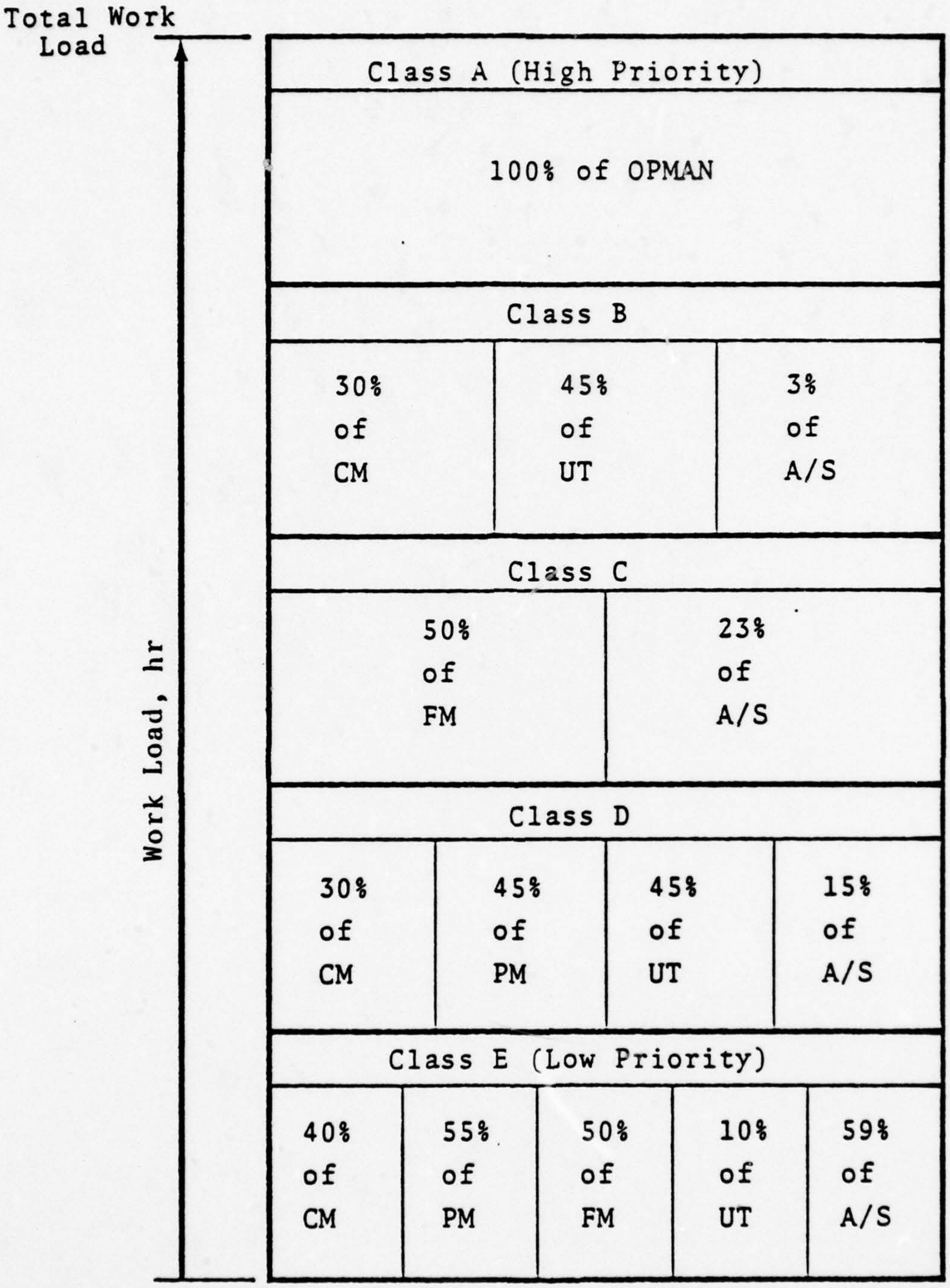

FIGURE F.2
NOTIONAL WORK PRIORITY SCHEME BASED ON SIMULTANEOUS WORK ACCOMPLISHMENT

Applying the Priority Scheme

F.8 The priority scheme is applied, work center by work center, to the cumulative deferral at a given point in the operating schedule (if the objective is to estimate the deferral by work category for a given set of conditions) or to the difference in deferral (if the objective is to estimate the increase or decrease in deferral due to a change in input parameters). In either case, the application may be made either at the end of the operating cycle (EOC) or at one of the nine other "windows" within the operating cycle that may be specified by the SWL algorithm user. Since the priority scheme application process has not been mechanized, only EOC breakdowns have been computed.

F.9 Specific Steps. The following are the specific steps used to apply the priority scheme to each work center. First, compute the average weekly work load for each priority for the work center:

A = 100% of OPMAN

B = 50% of CM + 45% of UT + 3% of A/S

C = 50% of FM + 23% of A/S

D = 30% of CM + 45% of PM + 45% of UT + 15% of A/S

E = 40% of CM + 55% of PM + 50% of FM + 10% of UT + 59% of A/S.

Second, determine the average weekly deferral AWD for the work center by dividing the cumulative deferral for the period under consideration by the number of weeks in the period under consideration, where the cumulative deferral is read directly from the SWL algorithm output. Third, compare the AWD with the priority scheme breakout of work load.

F.10 The results of the comparison from the third step will fall into one of several cases (refer to Figure F.3 for a graphic display of Cases A through F):

- AWD is zero. No work has been deferred
- AWD is the average weekly total work load. No work has been accomplished and, therefore, 100% of all work categories have been deferred
- Case A, where B + C + D + E is less than AWD, which is less than the average weekly work load (A + B + C + D + E). In this case, all work of priority Classes B, C, D, and E has been deferred, and part of the work in priority Class A has been deferred. The values of A, B, C, D, and E and AWD are computed as shown above; therefore, X_A may be determined:

$$X_A = A + B + C + D + E - AWD.$$

The amount of deferral for each work category is then simply found by adding the amounts in Classes E, D, C, B, and A, where the proportion in Class A is X_A/A.

Category	Deferral [1/]
CM	40% of CM (Class E)
	+ 30% of CM (Class D)
	+ 0% of CM (Class C)
	+ 30% of CM (Class B)
	+ 0 x X_A/A
	100% = total CM deferral

[1/] For simplicity, deferral is expressed here as a percentage of total category work load (i.e., 40% of CM = 0.4 (total CM work load)). In practice, the actual total work (Cont.)

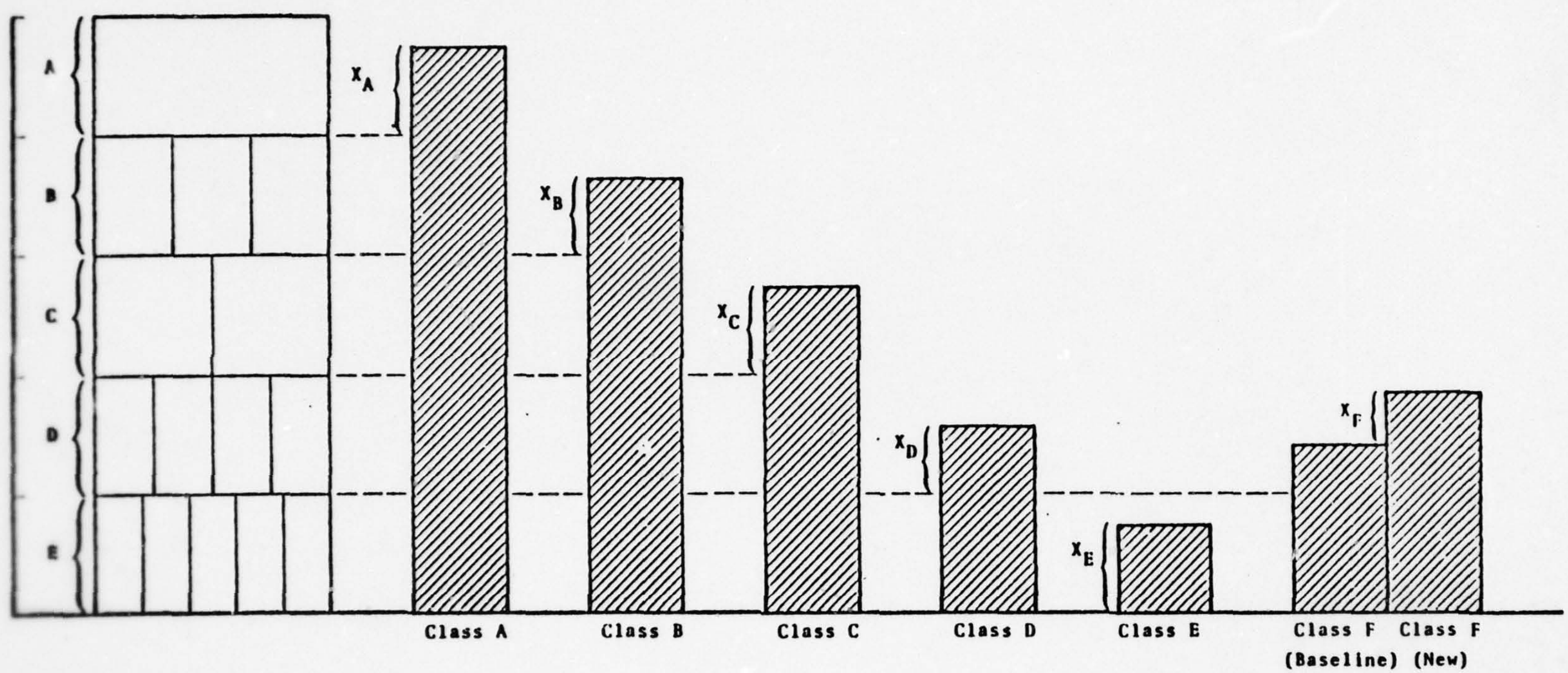

FIGURE F.3
COMPARISON OF AVERAGE WEEKLY TOTAL WORK LOAD WITH AVERAGE WEEKLY DEFERRAL

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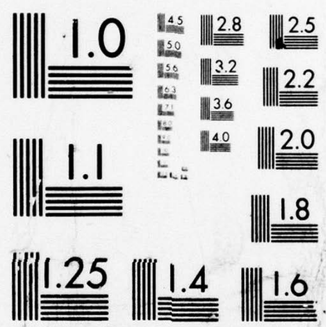

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Category	Deferral 1/
OPMAN	0% (Class E)
	+ 0% (Class D)
	+ 0% (Class C)
	+ 0% (Class B)
	+ 100% x X_A/A of OPMAN (Class A)
	100% x X_A/A = total OPMAN deferral

The final results for Case A are as follows:

Category	% Deferral
CM	100
PM	100
FM	100
UT	100
A/S	100
OPMAN	$X_A/A \times 100$

- Case B, where C + D + E is less than AWD, which is less than B + C + D + E. In this case, all work of priority Classes C, D, and E has been deferred, part of work of priority Class B has been deferred, and no work of priority Class A has been deferred. The amount of work in priority Class B that has been deferred is X_B/B, where

$$X_B = B + C + D + E - AWD.$$

The amount of deferral for each category is computed similarly:

1/ (Cont.) load by category is known and the results are expressed in hours of CM deferral, hours of PM deferral, etc.

Category	Deferral
CM	40% of CM (Class E)
	+ 30% of CM (Class D)
	+ 0% of CM (Class C)
	+ 30% x X_B/B of CM (Class B)
	70% + (30% x X_B/B) = total CM deferral

The results for each category in Case B are as follows:

Category	Deferral
CM	70% + 30% x X_B/B
PM	100%
FM	100%
UT	55% + 45% x X_B/B
A/S	97% + (3% x X_B/B)
OPMAN	0

- Cases C, D, and E. Similar computations are made for these cases. The AWD in each case is compared with the average weekly total work load. The result is that all of certain priority class work is deferral and a portion of one priority class work is also deferral. The results for Case C, where D + E is less than AWD, which is less than C + D + E, are as follows:

Category	% Deferral
CM	70
PM	100
FM	50 + (50 x X_C/C)
UT	55
A/S	74 + (23 x X_C/C)
OPMAN	0

For Case D, where E is less than AWD, which is less than D + E, the results are as follows:

Category	% Deferral
CM	$40 + (30 \times X_D/D)$
PM	$55 + (45 \times X_D/D)$
FM	50
UT	$10 + (45 \times X_D/D)$
A/S	$59 + (15 \times X_D/D)$
OPMAN	0

For Case E, where 0 is less than AWD, which is less than E, the results are as follows:

Category	% Deferral
CM	$40 \times X_E/E$
PM	$55 \times X_E/E$
FM	$50 \times X_E/E$
UT	$10 \times X_E/E$
A/S	$59 \times X_E/E$
OPMAN	0

- Case F. In this case, the objective is to determine the marginal change in deferral (by workload category) due to a change in SWL algorithm input parameters. For example, the objective may be to determine the marginal change in deferral due to a manning reduction. The baseline and new AWDs are obtained from separate SWL algorithm runs and compared with each other and the average weekly total work load. The results will be similar in appearance to those shown in Case F in Figure F.3. In this case, X_F is the increase in deferral. This increase is seen to occur in

priority Class D (due to the magnitude of the baseline and new AWDs), and, hence, the marginal increase in deferral is as follows:

Category	% Increase in Deferral
CM	$30 \times X_F/F$
PM	$45 \times X_F/F$
FM	0
UT	$45 \times X_F/F$
A/S	$15 \times X_F/F$
OPMAN	0

A similar table of change in deferral by category may be constructed should the new AWD cross into a higher priority class.

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